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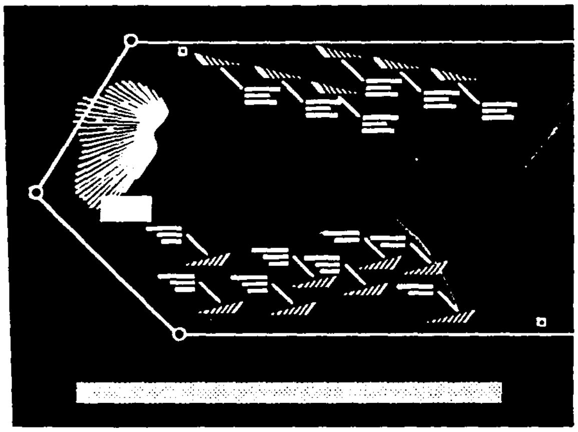
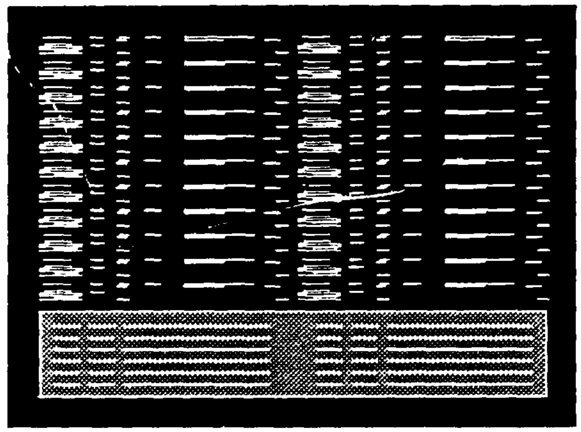
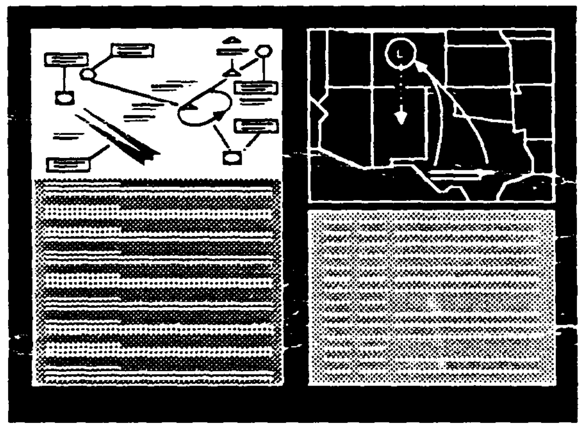




FAA AIR TRAFFIC CONTROL OPERATIONS CONCEPTS

Volume I: ATC Background and Analysis Methodology



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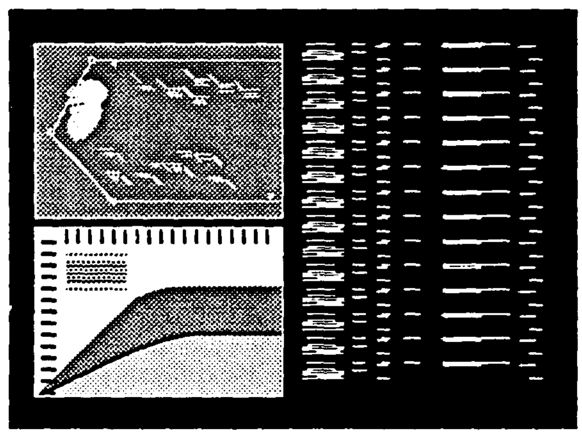

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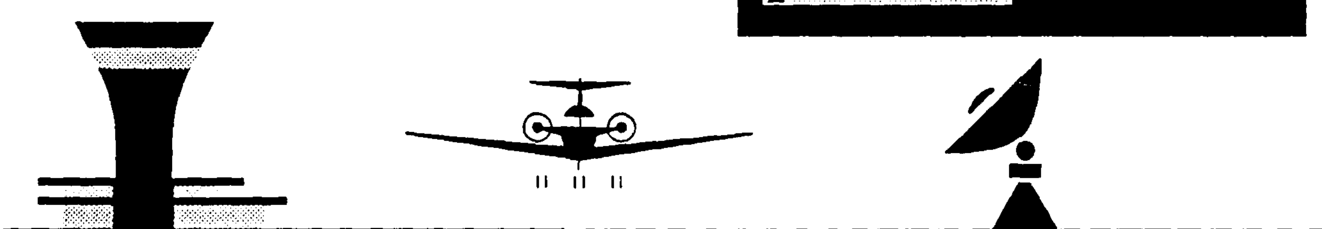

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16. Abstract

This submission updates Volume I, incorporating corrections and improvements as necessary. The series of volumes documents the operations concepts for operational (ATC) positions in the Advanced Automation System. AAS operational positions involve interaction with advanced radar and flight data displays, as well as other automated ATC functions, through a sector suite workstation or position console. Volume I of the series includes material common to all positions. Operations in todays facilities (pre-AAS Centers, Towers, and Terminals), the automated capabilities planned for AAS, and the methodology used to anlayze the operations concept for a particular ATC position are described in Volume I. Volume I includes definitions of air traffic events, baseline operational scenarios, glossaries of task and element action verbs, glossary of ATC terms, and list of acronyms used in the documents. Additional data volumes in this series include operations concept data pertinent to particular ATC positions and AAS segments. Updates caused by new editions of the AAS System Level Specification and other changes to any of these volumes will be issued as change pages to the original volume.

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VOLUME I: ATC BACKGROUND AND ANALYSIS METHODOLOGY

CDRL B112, VOL. I

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1-1 thru 1-6 (new)	1	3-18 thru 3-20	1	B-18 thru B-23	1
2-1 thru 2-2	O	3-21 thru 3-22	O	C-1 thru C-2	O
2-3 thru 2-4	1	3-23 thru 3-23b	1	C-3 thru C-8	1
2-5 thru 2-9	O	3-24	O	C-9 thru C-15	O
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2-11 thru 2-13	O	3-26	O	D-3 thru D-4	O
2-14	1	3-27 thru 3-28	1	D-5 thru D-23	1
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2-27 thru 2-29	1	3-39 thru 3-47	1	I-1 thru I-2	1
2-30 thru 2-33	O	3-48 thru 3-50	O	I-3	O
2-34 thru 2-35	1	3-51	1	I-4 thru I-5	1
2-36 thru 2-43	O	3-52 thru 3-53	O	I-6	O
2-44 thru 2-47	1	4-1	1		
2-48 thru 2-50	O	A-1 thru A-5	1		
2-51	1	A-6	O		
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2-57	1	A-9	O		
2-58	O	A-10 thru A-12	1		
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3-5 thru 3-8	O	B-10 thru B-11	O		
3-9	1	B-12 thru B-16	1		

Upon receipt of changes to this volume, remove superceded pages and replace with the appropriate change page. Below is a list of the formal changes detailed above and the effective date of each.

Change No.	Date
1	29 Jul 1988

FOREWORD

This document constitutes Volume I of a series of volumes which collectively define Air Traffic Control (ATC) Operations Concepts for the Federal Aviation Administration (FAA). This series was developed specifically to support the Advanced Automation System (AAS) and considers operations in today's facilities and the automated capabilities planned for the AAS in order to reach an understanding of how controller and other operational jobs will be performed as AAS evolves.

The AAS will provide enhanced capabilities to support operational ATC personnel in the en route, terminal, and tower environments; include automated capabilities to process and display surveillance data (targets, tracks, and weather), flight data, and environmental and status data, to assist the controller in maintaining a safe, orderly, and expeditious flow of traffic; provide supervisory and maintenance data and controls; and include message entry, information processing, and display outputs adaptable to the requirements and individual preferences of each controller. Ultimately, the AAS advanced automation features are expected to improve productivity by providing controllers with various strategic planning capabilities, while relieving controllers of certain routine control actions.

Evolution from the current system to the full AAS environment will progress through several major stages. This multi-volume series provides ATC personnel the Operations Concepts for selected operational positions in these different stages of AAS evolution. Currently volumes consist of the following:

- Volume I, ATC Background and Analysis Methodology - includes material common to all Operations Concepts analyses in subsequent volumes, and defines analysis concepts used in those volumes.

- Volume II, ACF/ACCC Terminal & En Route Controllers - addresses the domestic en route and terminal controller in the full AAS with Automated En Route Air Traffic Control (AERA) I capabilities.

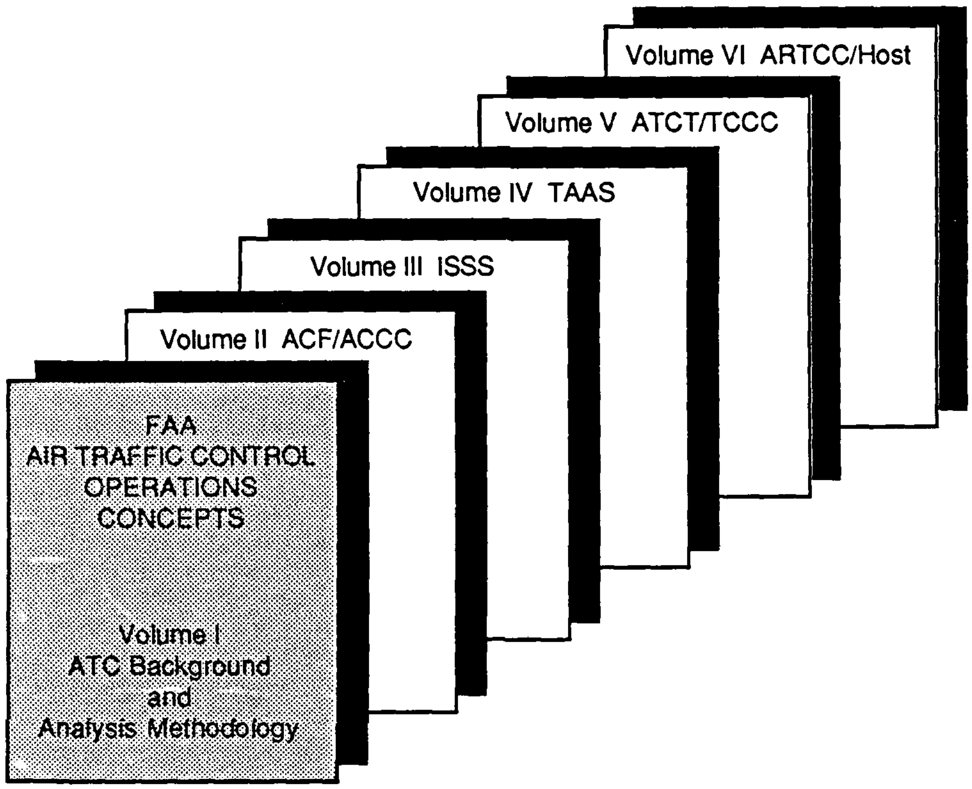
- Volume III, ISSS En Route Controllers - addresses the domestic en route controller in the Initial Sector Suite System (ISSS) environment.

- Volume IV, TAAS Terminal Controllers - addresses the terminal controller in the Terminal Advanced Automation System (TAAS) environment.

- Volume V, ATCT/TCCC Tower Controllers - addresses the tower controller in the Tower Control Computer Complex (TCCC) environment.

- Volume VI, ARTCC/Host En Route Controllers - addresses today's domestic en route controller in the Air Route Traffic Control Center (ARTCC)/Host environment.

Future volumes addressing other AAS phases and/ or operational positions will be published as required. The volumes currently identified are represented in the illustration (page vi).



FAA Air Traffic Control Operations Concepts Volumes

Volume I provides a brief overview of the current ATC environment and planned enhancements, as well as descriptions of the analysis methodology used to produce the operations concepts of subsequent data volumes. Each data volume focuses on one or more operational positions in a particular type of ATC facility at a specified stage of AAS development. Each of these data volumes is an operations concept describing how controllers will perform their operational duties, given the support of the automated capabilities provided at the specified stage of AAS development.

Configuration control procedures have been developed to ensure that operational requirements data are maintained for currency, completeness, and consistency with the AAS System Level Specification (SLS). This will be accomplished via change pages whenever possible rather than republishing a new or updated volume. **Substantive** changes to the original volume are indicated by a black line as shown in the margin of this paragraph. The "List of Effective Pages" (page iv) provides the current status of each page in this volume and will be updated with each subsequent change. Changes will reflect new design information and derived requirements resulting from design maturity, changes in specification requirements, and the impact of other AAS programs such as the Voice Switching and Control System (VSCS) and the Real Time Weather Processor (RWP).

The value of the final results rests heavily upon contributions of those active in and familiar with the present system. The authors wish to express their thanks to the following members of the Sector Suite Requirements Validation Team (SSRVT) who, in addition to providing much valuable time and insight into operational matters, also provided detailed review and validation of the contents of these volumes:

NAME	FACILITY
Gary Badger	Anchorage ARTCC
Richard Banks	Denver TRACON
Richard Chavez	Albuquerque ARTCC
Carlisle Cook	Atlanta ARTCC
Don Dunn	Sacramento TRACON
Max Hall	Salt Lake City ARTCC
Thomas Lane	Atlanta ARTCC
Marty Lilly	New York TRACON
Marvin Perkins	Jacksonville ARTCC
Ralph Procaccini	Kansas City ARTCC
Terry Schomburg	Waterloo ATCT
Jim Sheely	Charlotte ATCT
Kathy Vargo	Flint ATCT
John White	Indianapolis ARTCC
John Williams	Portland ATCT
Floyd Woodward	ATR-210

Providing valued support to the continued efforts of the SSRVT are: Richard Barker (ATR-150), Gail Garwood (ATR-150), L. Lane Speck (ATR-100), and Frank Yohe (AAP-100).

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LIST OF FIGURES AND TABLES

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SECTION 1

INTRODUCTION

1.1 PURPOSE

This volume is primarily an introductory volume which includes material generally applicable to all subsequent data volumes (Operations Concepts analyses). It includes an introduction (Section 1), brief overviews of the current ATC environment and planned enhancements (Section 2), and descriptions of the analysis methodology (Section 3) used to produce the operations concepts of the subsequent data volumes.

1.2 ATC BACKGROUND

The ATC system incorporates a combination of control equipment, techniques, procedures, and skills that have evolved over 50 years. This evolution has produced a mixture of equipment of many ages, technologies, and types. It has become expensive to operate and maintain, expansion capability is limited, and adaptability is low The existing system was designed around the concept that airspace can be partitioned into airspace volumes (i.e., sectors/positions) such that controllers can monitor and maintain separation between aircraft, and obstacles to aircraft. The primary manned operational elements include the Air Route Traffic Control Center (ARTCC), the Airport Traffic Control Tower (ATCT), the Terminal Radar Approach Control (TRACON), and the Terminal Radar Approach Control in the Tower Cab (TRACAB). The new AAS will accommodate the increasing air traffic demand, reduce risks of traffic incidents, increase controller productivity, and reduce the technical staff required to operate the modernized and expanded system.

1.3 ANALYSIS METHODOLOGY

The focus of the analysis methodology is on the controller's operational tasks and the requirements they imply in the area of information exchange between the controller and the automated system. The methodology is designed to include information entered by the controller into the system, information generated for and displayed to the controller by the system, and information exchanged between the controller and others with the support of the system. The goal is to facilitate an AAS design that provides an effective dialogue between the controller and the automated system. (In this context, "controller" refers to any type of operational control position, including supervisory positions.) No specific design to meet AAS requirements is assumed or suggested.

Tasks are described in terms of message inputs, display outputs, and operational performance attributes. An assessment of controller workload is provided within the framework of human information-processing tasks and associated performance levels by control position. The information-processing tasks are considered to include logical (cognitive) and perceptual components. These components will of necessity have an impact on the subsequent formulation of information coding/presentation requirements and interaction techniques.

The purpose of the methodology is to develop data volumes that will serve as vehicles for assessing the operational suitability of the AAS Acquisition Phase (AP) contractor's design and for developing test, training, and operational procedures. It is intended that data developed by the

methodology will also be found useful by developers of certain systems interfacing with the AAS, such as the Voice Switching and Control System (VSCS), the Tower Communications System (TCS), the Advanced Traffic Management System (ATMS), and the Real Time Weather Processor (RWP).

1.4 OPERATIONS CONCEPTS ANALYSES

The various Operations Concepts analyses document the air traffic control MMI operational requirements baseline for the FAA's AAS and are contained in data volumes appropriately titled. These analyses portray operational duties of FAA ATC personnel in the evolving AAS environment from the controller's viewpoint. Although the focus is on interaction between the controller and the automated system, operational controller tasks involving no interaction with the system are included where appropriate. The analysis excludes non-operational tasks such as administrative tasks and tasks related to training, which form an important part of the job for all positions. Non-FAA controllers are not addressed.

Each ATC facility exhibits unique features. The amount and composition of the workload varies significantly from one facility to the next, and varies within a particular facility over time. Tasks that are performed frequently in one facility may be rare in another. The situation in some facilities necessitates special control positions, such as the Helicopter Control and Gate Hold positions found in certain large Towers. Such interfacility differences are less substantial between en route Centers than between Towers, but exist in all types of facilities. Therefore, each analysis presented in this document addresses a "generic" facility, where the analysis is broad enough to capture all significant tasks performed in any facility of the type addressed. Separate control positions are analyzed if, and only if, the differences between them are significant. Thus, for instance, the R and D controllers in the en route facility are treated as a single position because they work as a unit. Tower Controllers are separately analyzed for the three prime positions of Local Control, Ground Control, and Clearance Delivery/Flight Data. Each volume of the analysis describes its assumed breakdown of control positions, if appropriate. Tasks performed very infrequently are omitted, unless they are of overriding criticality when they occur.

1.5 ASSUMPTIONS

The global assumptions common to all of the Operations Concepts analyses are identified in this subsection. Other assumptions pertaining to specific analyses are identified in the appropriate data volumes. The common global assumptions are:

a. Automated capabilities provided through the AAS and other programs, while they may change the way certain tasks are performed and may create new tasks while eliminating others, will not alter basic ATC functions or the general duties and responsibilities of controllers, supervisors, and other operational personnel.

b. Controllers and other system users may be characterized as event-sensitive; that is, acting generally in response to or anticipation of Air Traffic events rather than initiating action independently. The term "event" as used here encompasses both actual occurrences such as status changes, and predicted occurrences such as a predicted aircraft conflict. See Appendix A.

c. AAS functionality and interfaces will be as described in the AAS System Level Specification [21], except where an assumption to the contrary is specifically identified.

d. Automated En Route Air Traffic Control (AERA) automation features as noted in Section 2.2.5 will apply only to high-altitude en route traffic through the AAS/AERA 1 period.

e. Controllers will interface with the automated en route/terminal systems via the sector suite consoles and the automated tower system via the tower position console.

f. A nationwide Advanced Traffic Management System will be implemented such that traffic management actions at Tower, Area Control Facility, and national levels will be fully coordinated.

g. Mode S Data Link capability will be implemented concurrently with AERA 2 enhancements. Prior to this, there will be no Mode S Data Link capability, and all communications between controller and pilot will be by voice.

h. The ATC Mail or General Information (GI) capabilities will be available for communication among controllers in Centers, Terminals, and/or Towers.

i. Evolution from current *modus operandi* to full AAS (including Area Control Facilities) will conform to the National Airspace System Plan [20].

1.6 DOCUMENT INTERFACE

The Operations Concept analyses contained in the data volumes (currently Volumes II - VI) were developed from the methodology defined in Volume I. Thus, Volume I is the common denominator for each of these Operations Concepts and necessary for full understanding of each. Several appendices in Volume I are also of particular importance to the subsequent data volumes. These appendices are listed here for the convenience of users:

- Appendix C, Task and Element Verb Glossaries
- Appendix D, Glossary of Terms
- Appendix G, References
- Appendix H, List of Acronyms
- Appendix I, Index.

Publications listed in Appendix G are cited throughout these volumes. When this is done, the reference number from Appendix G is provided in brackets [ ].

All data volumes follow a common format. The general text of Volume I is amplified and/or modified if appropriate in Section 1 of the data volumes. Section 2 describes any special features of the methodology applicable to the particular data volume.

Data developed through the analysis methodology discussed in Volume I are presented in the following appendices common to the data volumes:

Appendix A: Composition Graphs

Appendix B: Task Statements and Event to Sub-activity Trace

Appendix C: User Interface Language

Appendix D: Task Characterization Analyses

- Task Information Requirements
- Cognitive/Sensory Attributes
- Performance Requirements
- *Deleted*

Appendix E: Task Element Statements

Appendix F: Traceability Tables

Appendix G: *Site Visit Information* (as applicable)

Appendix H: Expanded Operational Scenarios

Appendix I: Other Analysis Results (as applicable)

Appendix J: Site Visit Materials (as applicable).

Table 1.4-1 traces between each section of the methodology discussion in Volume I and the related analysis results documented in Volume I and/or the data volumes.

Table 1.4-1. Document Overview		
TOPIC	**METHODOLOGY**	**DATA**
Air Traffic Events	Volume I, Section 3.2.1	Volume I, Appendix A
Controller Task Analysis		
Decomposition to Activities, Sub-Activities, and Tasks (Composition Graphs)	Volume I, Section 3.2.2	Data Volumes, Appendix A
Event - Sub-Activity Trace	Volume I, Section 3.2.2	Data Volumes, Appendix B
Controller Task List	Volume I, Section 3.2.3	Data Volumes, Appendix B
Task Verb Glossary	Volume I, Section 3.2.4	Volume I, Appendix C
Deleted		
Operational Scenarios	Volume I, Section 3.2.6	Volume I, Appendix B; Data Volumes, Appendix H
User Interface Language	Volume I, Section 3.3	Data Volumes, Appendix C
Task Characterization Analyses		
Task Information Requirements	Volume I, Section 3.4.1	Data Volumes, Appendix D
Cognitive/Sensory Attributes	Volume I, Section 3.4.2	Data Volumes, Appendix D
Performance Criteria	Volume I, Section 3.4.3	Data Volumes, Appendix D
Deleted		
Controller Task Elements		
Task Element Statements	Volume I, Section 3.5.1	Data Volumes, Appendix E
Element Verb Taxonomy	Volume I, Section 3.5.2	Volume I, Appendix C
Task Element Modules	Volume I, Section 3.5.3	Volume I, Appendix F
Assumed Quantities of Data Objects	Volume I, Section 3.5.4	Data Volumes, Appendix E
User Review		
Site Visits	Volume I, Section 3.6.1	Data Volumes, Appendix G
User Group Validation	Volume I, Section 3.6.2	Throughout analysis - results not explicitly identified
Traceability	Volume I, Section 3.7	Data Volumes, Appendix F

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SECTION 2

ATC BACKGROUND

This section provides a description of the current Air Traffic Control system and its progression into the future.

The National Airspace System (NAS) encompasses a network of U.S. airspace; air navigation facilities; equipment and services; airports or landing areas; aeronautical charts; information and services; rules, regulations, and procedures; and technical information, personnel, and material. Included in the NAS are system components shared jointly with the military.

Within the NAS is a service that promotes the safe, orderly, and expeditious flow of air traffic, including airport, approach/departure, and en route Air Traffic Control (ATC). The ATC system incorporates a combination of control equipment, techniques, procedures, and skills that have evolved over 50 years. This evolution has produced a mixture of equipment of many ages, technologies, and types. It has become expensive to operate and maintain, expansion capability is limited, and adaptability is difficult.

Terminal and en route controller operations can be characterized in terms of the relationships between the ATC external environment and the operations at the en route and terminal facilities. This concept is illustrated in Figure 2.0-1. This figure shows that the ATC external environment is composed of airspace, weather, aircraft, airway/airport facilities, and surveillance capabilities.

Airspace is bounded by geography, terrain, obstacles, airway route structure, and weather. *Aircraft* are functionally related to *airspace* through route structures or random routes. Aircraft movement can be characterized as IFR (Instrument Flight Rules) or VFR (Visual Flight Rules). Within the VFR category there may be further distinctions made, such as Controlled VFR, Special VFR, etc. Aircraft can also be designated as either commercial, military, or general aviation. The term *airway/airport facilities* here is used to denote airports, runways/taxiways, ATC equipment, and navigation aids. These facilities are directly related to *aircraft* and *airspace* in the sense that aircraft flying published routes rely on navigational aids for en route and arrivals/departures at airports which may be affected by terrain, obstacles, and *weather*. *Surveillance capabilities* concern radar coverage of *aircraft* and *weather*.

The importance of the relations among airspace, aircraft, facilities, and surveillance capabilities from the controller perspective is that *events* (see Section 3.2.1 and Appendix A) can be characterized in terms of these components, e.g.:

- Airway route configuration, traffic volume and complexity, and weather affect the manner in which controllers separate and expedite traffic. Weather related events may include IFR minimums which reduce runway capacity. Obstacles and terrain require the controller to maintain aircraft at safe minimum altitudes.

- Aircraft movement may trigger events such as amendments to the original clearance or flight plan, application of preferential routing, missed approaches, loss of radio contact, and potential conflicts with terrain, aircraft, or special use airspace. Aircraft are controlled as a function of weather, airspace, and sensor coverage.

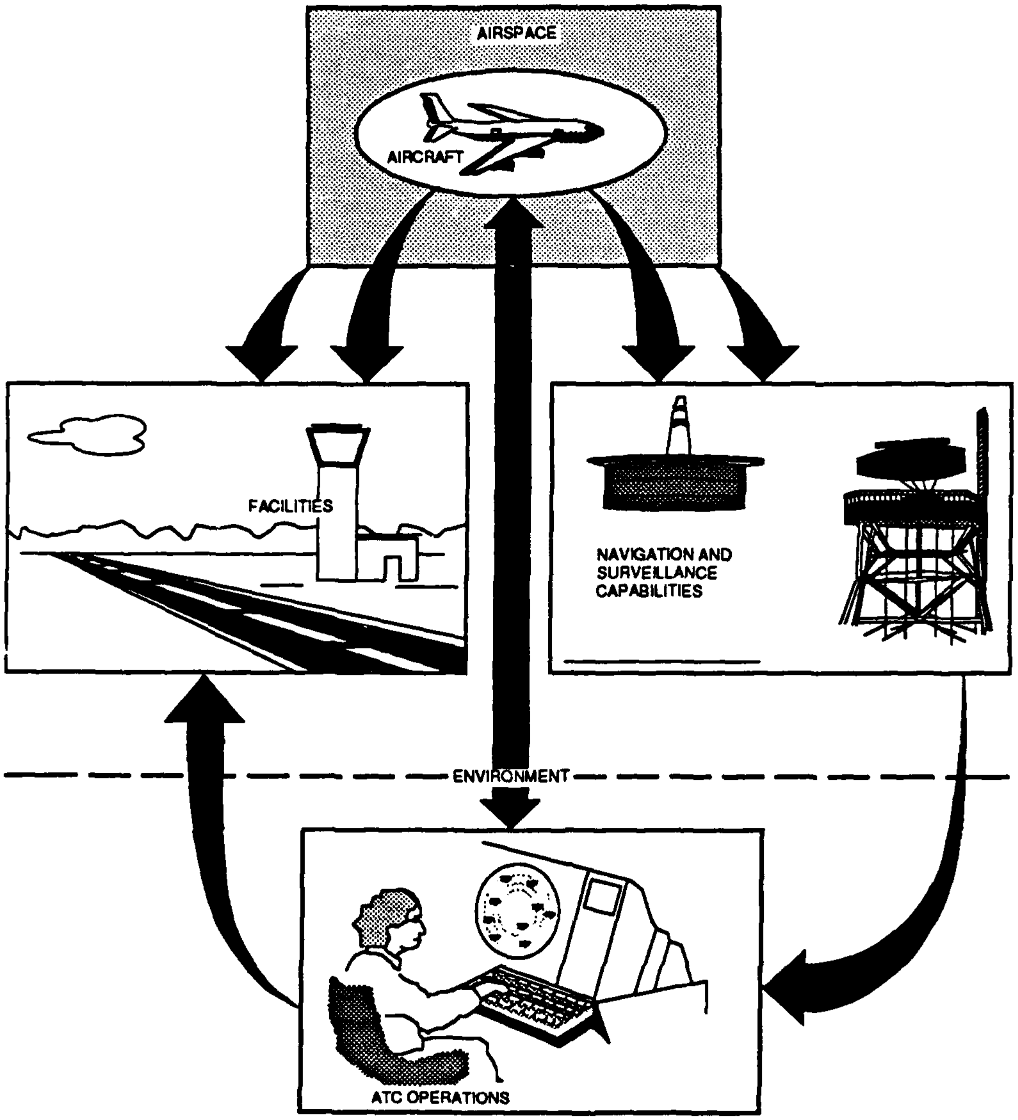


Figure 2.0-1. ATC Environment vs ATC Operations

- Facilities such as airports and runways are resources affected by the weather to which ATC operations are restricted or metered.

- Surveillance displays and flight progress strips provide the controller with the capability to determine the situation and take planned actions to provide safe, orderly, and expedious flow of traffic.

The National Airspace System (NAS) Plan [20] outlines the objective of the full Advanced Automation System (AAS). It is to provide for the consolidation of the terminal approach control facilities underlying the Air Route Traffic Control Centers (ARTCCs) into a new facility called an Area Control Facility (ACF). The collocated facilities will be responsible for performing all aspects of ATC arrival, departure, and en route services. A distinction will not be made between en route and terminal operations since the ultimate goal is to integrate these functions. A distinction is made according to the sector/position types to assure the characteristics of the sectors/positions are understood and preserved. The concept of ACF operations, including an overview of how the individual controller will be employed, is summarized in Section 2.2.2. The description is based upon the current AAS System Level Specification [21] and the NAS Plan [20].

To promote an orderly transition into the ACF and early use of the sector suite equipment, it is intended to implement the Initial Sector Suite System (ISSS) using the Host computers (currently being installed in ARTCCs), and start the replacement in TRACONs of the Automated Radar Terminal System (ARTS) with the Terminal Advanced Automation System (TAAS). The ISSS will be used by the en route controllers, using the new Sector Suite workstation equipment and Man-Machine Interface (MMI). The TAAS will be used by the Terminal Radar Approach Control (TRACON) controllers. TAAS will provide the functionality of the ARTS using the programs, equipment, and MMI of the AAS using Sector Suite equipment.

These two systems, TAAS and ISSS, subsequently are to be merged into the Area Control Computer Complex (ACCC), which will process the data for the eventually collocated terminal and en route facilities. Some of the future improvements planned for the system are the Real Time Weather Processor, Automation Processing (AERA I, II, III), the Advanced Traffic Management System, and Mode S and data link.

Subsequent to the Terminal Advanced Automation System will be automation designed for the Airport Traffic Control Tower (ATCT). This system is known as the Tower Control Computer Complex (TCCC). The TCCC will support the controller positions found in the Tower. Although a subset of the hardware/software of the ACCC may be used, much of the equipment interfacing with the Tower controller will be unique because of the visual aspects of the Tower controller's environment and operations. Controllers at TCCC-equipped ATCTs will interface with the TCCC through the use of Tower Position Consoles.

2.1 DEVELOPMENT OF THE CURRENT ATC SYSTEM

The existing system was designed around the concept that airspace can be partitioned into airspace volumes (i.e., sectors/positions) such that controllers can monitor and maintain separation between aircraft, and obstacles to aircraft. Sectors and positions are grouped into clusters or areas of specialization within the ATC facility. Normally an en route full performance level controller will be certified to work approximately six sectors, which constitute the area of specialization.

Fundamental to the ATC operation is the concept of providing separation to aircraft. This action on the part of controllers is a function of FAA separation standards, facility directives, division of airspace responsibility, and adaptation to the external ATC environment. The controller must formally transfer aircraft control between sectors in an Air Route Traffic Control Center (ARTCC) or positions at a Terminal (TRACON/TRACAB) facility. This may also involve transfer of control between sectors/positions with adjacent facilities.

Figure 2.1-1 provides an overview description of the operating elements of today's ATC system. As shown in the figure, the primary manned operational elements include the Air Route Traffic Control Center (ARTCC), the Airport Traffic Control Tower (ATCT), the Terminal Radar Approach Control (TRACON), and the Terminal Radar Approach Control in the Tower Cab (TRACAB). The non-radar approach control facility is not shown in this figure, since there are so few such facilities and their functions usually are accomplished by controllers in ARTCCs.

Surveillance systems are composed of airport surveillance and long range radars and common digitizers which provide digital input into the air traffic control computer systems. The en route system is referred to as the Host Computer System and provides automated tools to Center controllers in the form of radar data displays and printed flight progress strips. The terminal computer systems consist of Automated Radar Terminal System (ARTS) II, IIA, III, or IIIA. The ARTS provides for aircraft identification, tracking, and associated display. Facilities are interconnected either by a National Communications (NATCOM) facility or by local telecommunications interfaces. Pilots and controllers communicate using air-to-ground radio frequencies.

2.1.1 Air Route Traffic Control Center

The Air Route Traffic Control Center (ARTCC), commonly known as the "Center," is the largest of the Federal Aviation Administration's Air Traffic Control facilities. See Figure 2.1-2 for a picture of a present-day ARTCC building. The first three en route ARTCCs were established by the airlines and were taken over in 1936 by the Bureau of Air Commerce. The number of Centers grew to 29 before being consolidated into 20 continental U.S. and 3 offshore ARTCCs.

2.1.1.1 ARTCC Development

For many years, air traffic controllers provided separation of en route air traffic by communicating with either an airline company or an agency communications station. Direct pilot-to-controller communications had been tried on an experimental basis but was met with objections by controllers who did not want to listen to the noisy frequencies. The late 1940s brought very high frequency (VHF) radio communications to the air traffic system. It would still be several years before remote air-ground communications would be available throughout the country.

The airway structure was made up of low frequency navigational aids, which also were used for non-precision approaches as well as guidance along the airways. There was a heavy dependence upon visual in-flight conditions as a means of providing the necessary separation between aircraft.

Few enhancements were made to the air traffic system until after June 30, 1956, when a Trans World Airlines Super Constellation and a United Airlines DC-7 crashed in the vicinity of the Grand Canyon. One of the flights was cruising at an altitude of 21,000 feet and the other was flying at least "1000 feet on top" of all clouds. Neither was under air traffic control jurisdiction since they

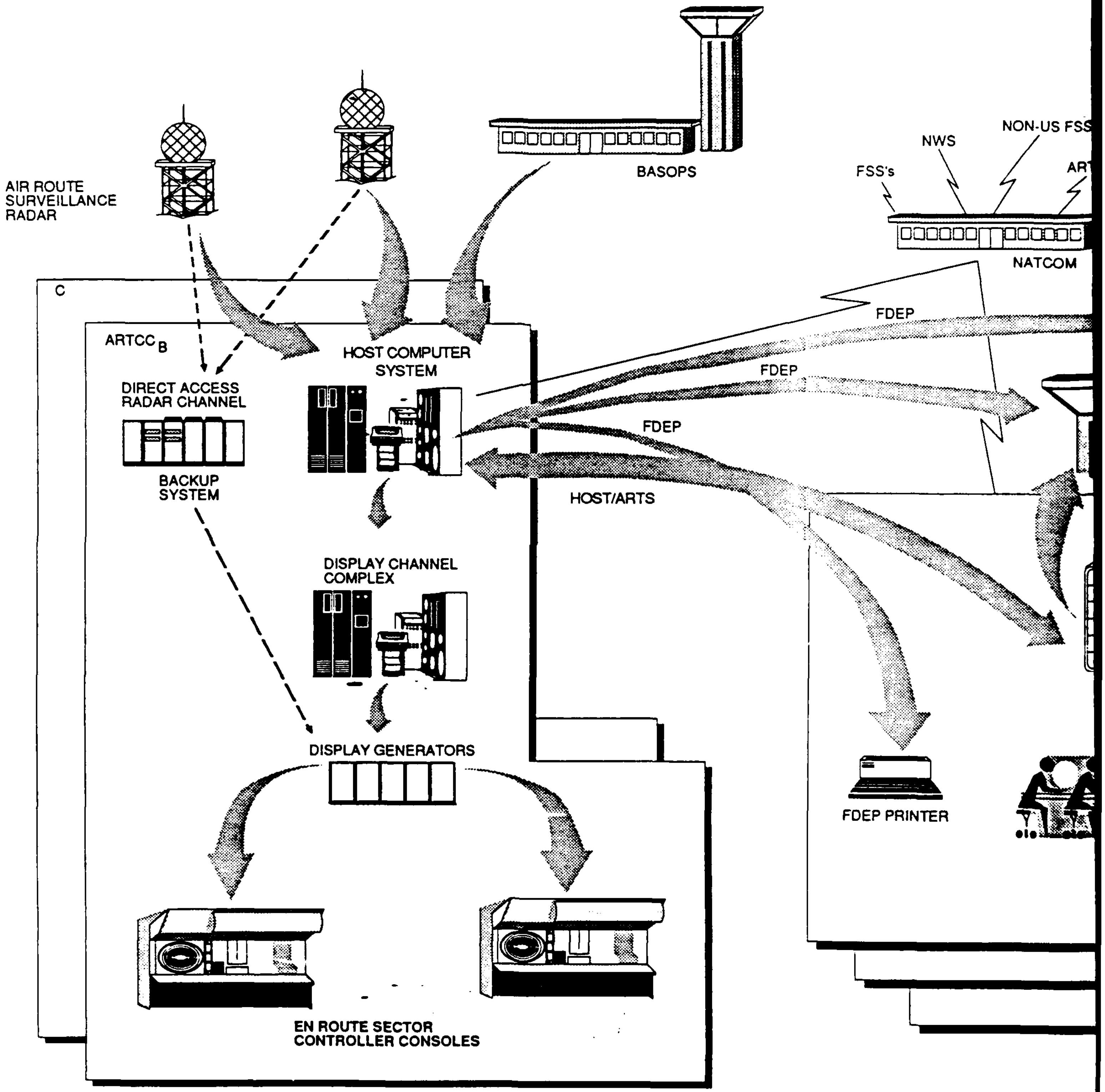
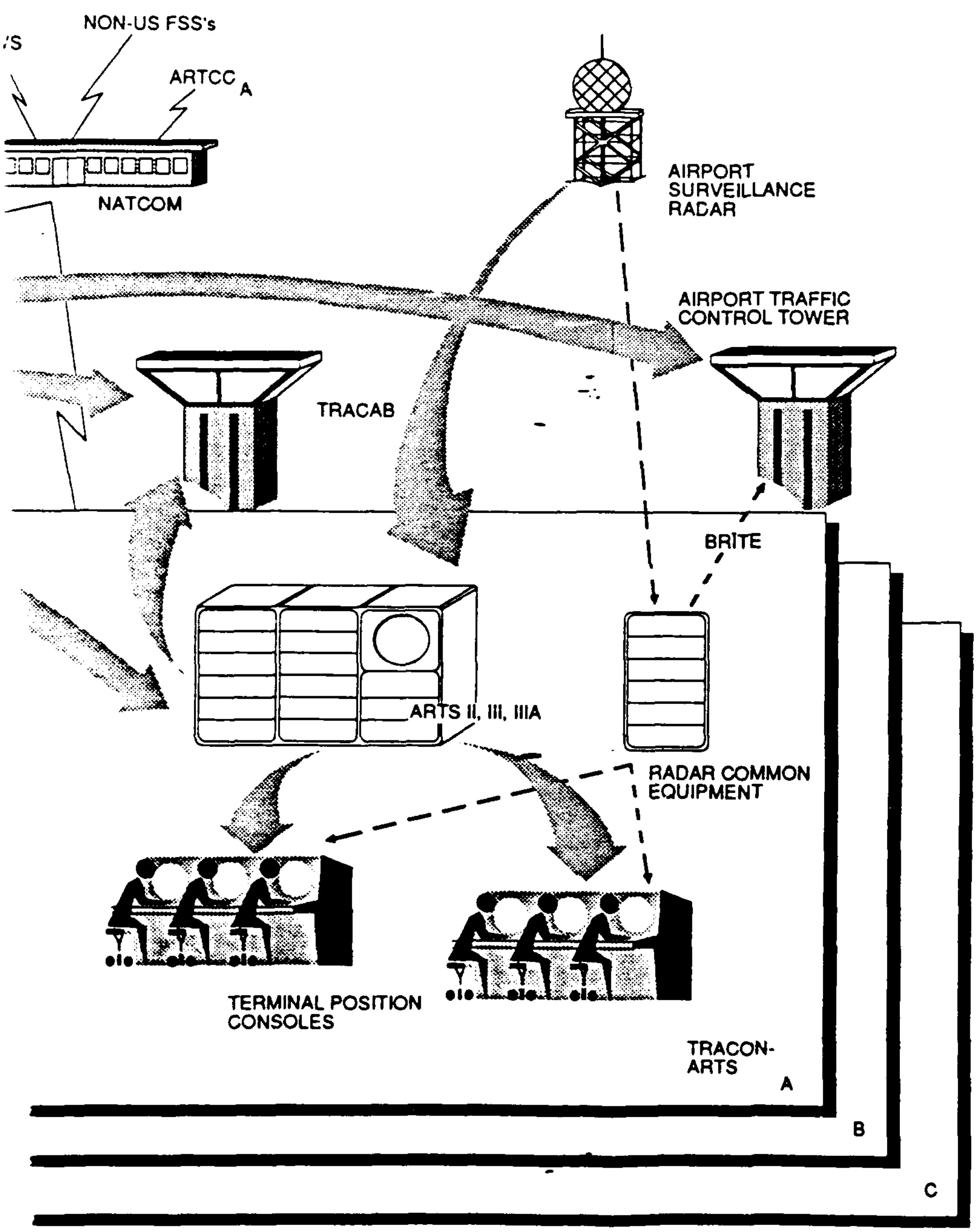


Figure 2.1-1. Operational Elements of Current ATC Syste



ent ATC System

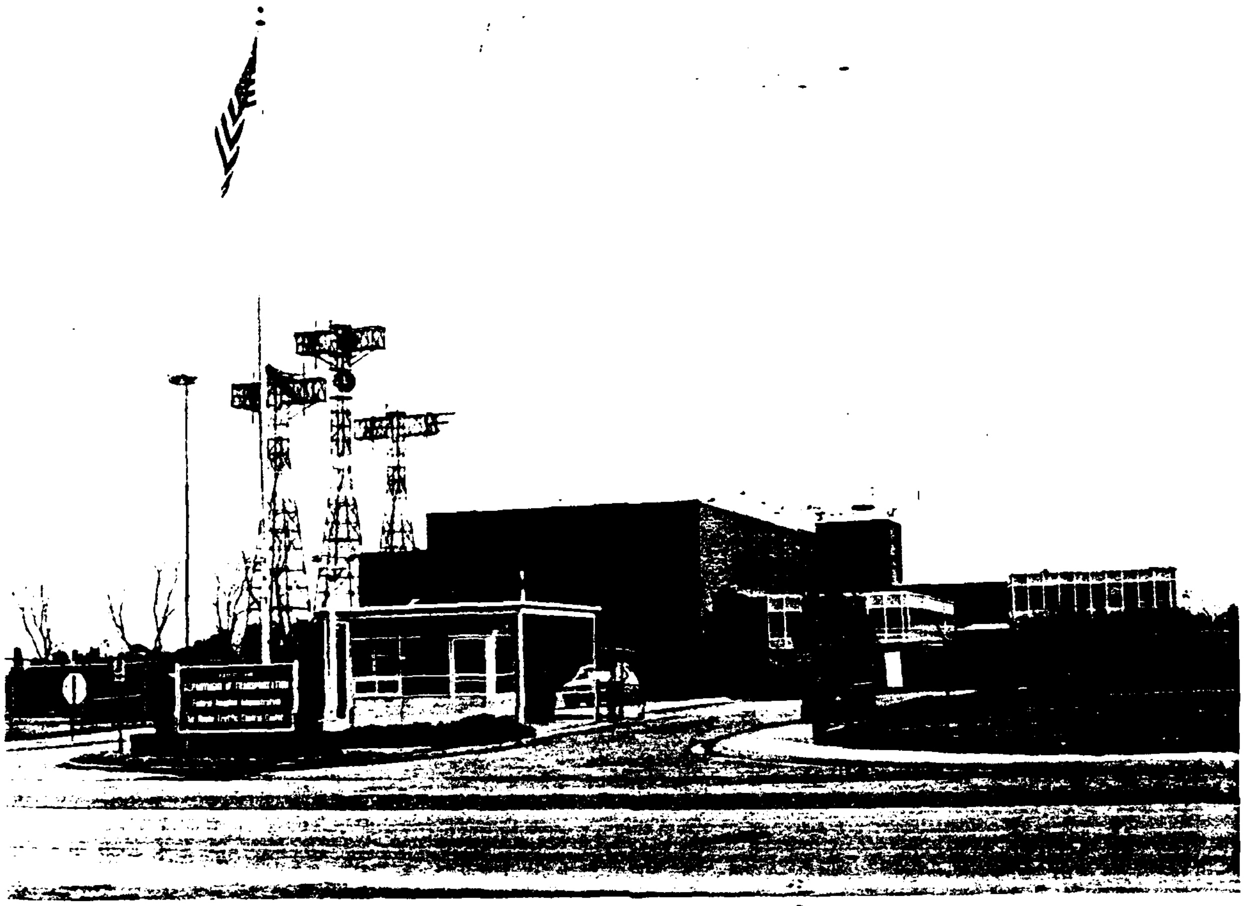


Figure 2.1-2. Present-day ARTCC Building

had both departed the confines of the federal airway system. Both aircraft were obligated by the "see and be seen" rule. The investigation and eventual outcome of this tragic event was to have major impact on the advancement of the air traffic system.

Up to this point Air Traffic Control (ATC) services were available only on the limited number of established airways, which were in the transition from the low frequency navigation system to the more advanced VHF Omnidirectional Ranges (VORs). Delays were extreme when weather conditions required flight in Instrument Flight Rules (IFR) conditions. This was especially true between major cities.

It was not until the late 1950s that long-range radar became a part of the ATC system. The initial radar displays were often used by more than one controller, controlling different airspaces on the same radar scope. Although the quality of the presentation was often poor, compared to today's radar, it provided for a much enhanced service over manual control methods.

During the early 1960s, the commercial jet age was becoming a reality. This placed an additional burden on the system and new procedures were necessary to provide increased safety of flight for the user. In 1962 and 1963, positive controlled airspace at 24,000 feet and above was implemented in parts of the country, and a year later this enhancement became a reality throughout the 48 contiguous United States. Today's environment includes positive controlled airspace at 18,000 feet and above. Construction of new en route traffic facilities was taking place in the early 1960s, replacing the overcrowded and outdated facilities of the past.

In this same time period, the FAA began efforts to apply automation techniques to its flight data processing systems. By using UNIVAC and IBM equipment in six Centers in the northeast, the FAA determined that computers could be used to improve safety and increase the productivity of the controller. The computers used in Centers produced flight progress strips that reported flight information such as route of flight and altitude for each sector an aircraft passed through. The initial system did not have amendment updating capability, but printed out all flight strips at one time, with no keyboard for entry of changes.

In 1968, a plan to automate many of the functions of the en route Air Traffic Control system was approved. The system was called NAS Stage A, and contained several models for staged implementation. The first model was tested at the Jacksonville ARTCC. This system was an important development, but was not implemented nationally. A National Air Traffic Coordination (NATAC) Committee, consisting of air traffic facility data systems specialists (who were former journeyman controllers) and air traffic headquarters specialists, was formed to define air traffic requirements and specifications. This led to the successful merging of the Flight Data Processing (FDP) and Radar Data Processing (RDP) computer programs.

Many other enhancements followed from the late 1960s to the present, including conflict alert, digitized radar backup systems, and others, providing the en route air traffic controller with the latest tools available in the system.

2.1.1.2 ARTCC Airspace

This section describes the concepts of controlled airspace and the airway route structure. This is descriptive of the current operational environment.

Controlled Airspace

The controlled airspace over the United States consists of areas designated as the Continental Control Area, Control Areas, Control Zones, Terminal Control Areas, and Transition Areas.

When an area is designated as a controlled area, it is supported by Air Traffic Control services, communications, and navigational aids. All other areas are designated as uncontrolled airspace. Air Traffic Control has neither the authority nor the legal responsibility for exercising control over air traffic in uncontrolled airspace. See Figure 2.1-3 for the various types of airspace and Table 2.1-1 for a description of controlled airspace categories.

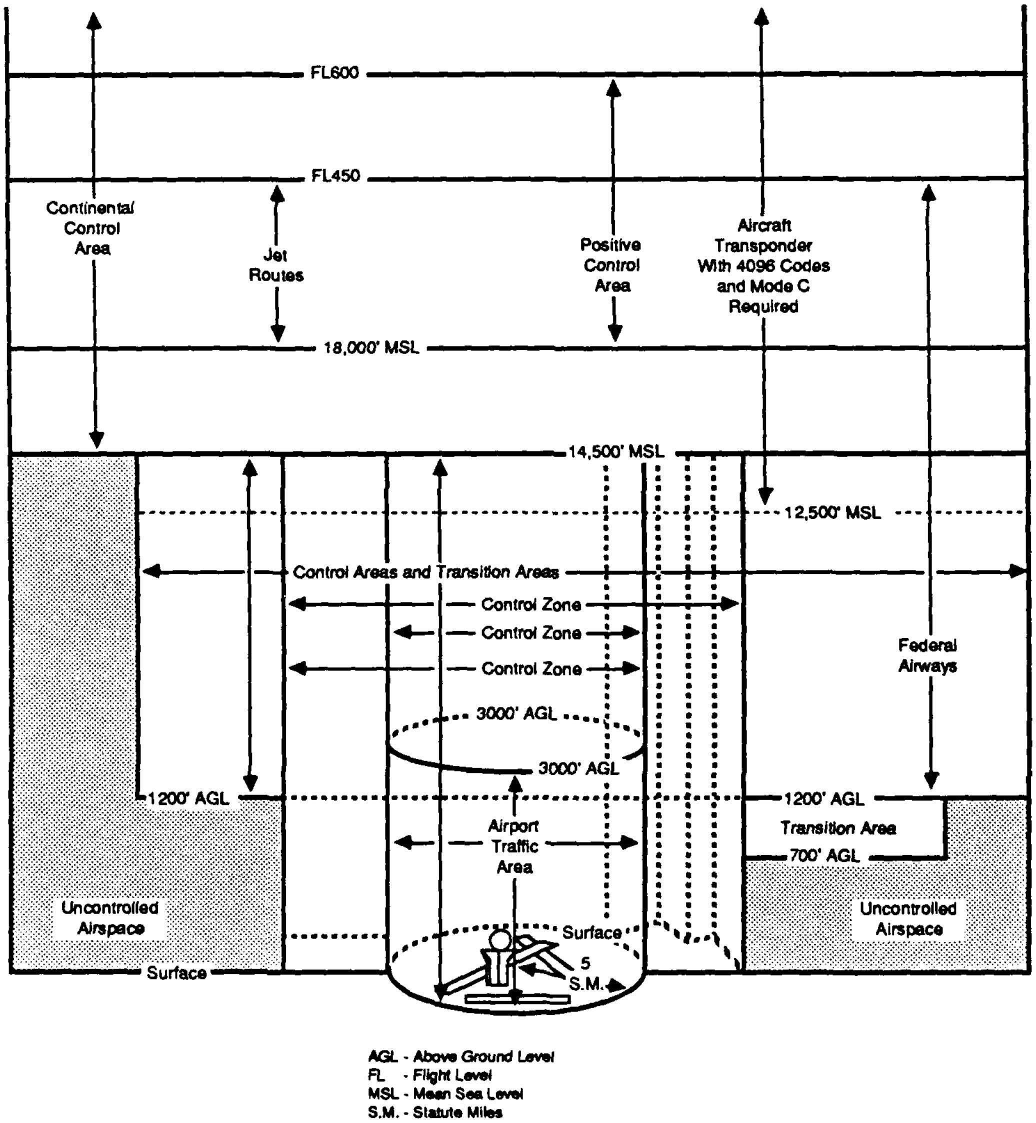


Figure 2.1-3. Controlled Airspace

Table 2.1-1. Definition of Airspace Categories

Continental Control Area	The Continental Control Area consists of airspace above 14,500 feet, or 1,500 feet above surfaces higher than 14,500 feet, of the 48 contiguous states and part of Alaska.
Control Areas	Control Areas include the airspace associated with all federal airways.
Control Zones (CZs)	Control Zones extend from the surface up to the Continental Control Area and include one or more airports. The control zone is normally a circular area within a 5 mile radius and may include an extension necessary for an instrument approach or departure.
Terminal Control Areas (TCAs)	Terminal Control Areas are controlled airspace which require all aircraft to comply with special operating rules and equipment requirements. The airspace extends from the surface to specified altitudes in the TCA. The lateral limits of the TCA are based on distance from the primary airport, and vary with altitude, often giving the appearance of an upside down wedding cake.
Positive Control Area	Positive Control Area is designated in the 48 contiguous states and parts of Alaska as airspace within which all aircraft are subject to operating requirements.
Transition Areas	Transition Areas are designed to contain IFR operations in controlled airspace transitioning the terminal and en route environment. These airspace designations extend from 700 feet, in conjunction with an instrument approach, or 1,200 feet in conjunction with an airway, upward to the base of the overlying controlled airspace.
Special Use Areas	In addition to controlled airspace there are several special use areas. These areas are Prohibited Areas and Restricted Areas. Prohibited Areas are defined as areas where aircraft flights are prohibited. Restricted Areas are not wholly prohibited but may only be entered with authorization from the controlling agency. Other special use areas, such as Military Operations Areas, (MOAs), can be transitted without an ATC clearance if operating under VFR or with a clearance if operating under IFR.

Route Structure

Airway navigation today still uses the low (Victor) airways and the high (Jet) airways that were established in the 1960s. The use of Area Navigation (RNAV) routes is minimal. The accuracy of the navigation systems and the capability of aircraft to navigate accurately using the prescribed routes and landing systems are major factors in any possible future decision to reduce separation standards.

Low Altitude Airways

Normally, the low altitude airways are designated from 1,200 feet above ground level up to 17,999 feet. The azimuth feature of the VORs and VORTACs is used in the establishment of the route structure. The VOR, "V" or Victor, airways are even numbered east/west and odd numbered north/south. The "V" is followed by a discrete number to form a specific airway, e.g., V2, V137, etc. Normally, the lateral limits are up to 4 nautical miles on either side of the center line. See Figure 2.1-4 for a depiction in chart form of a low altitude airway.

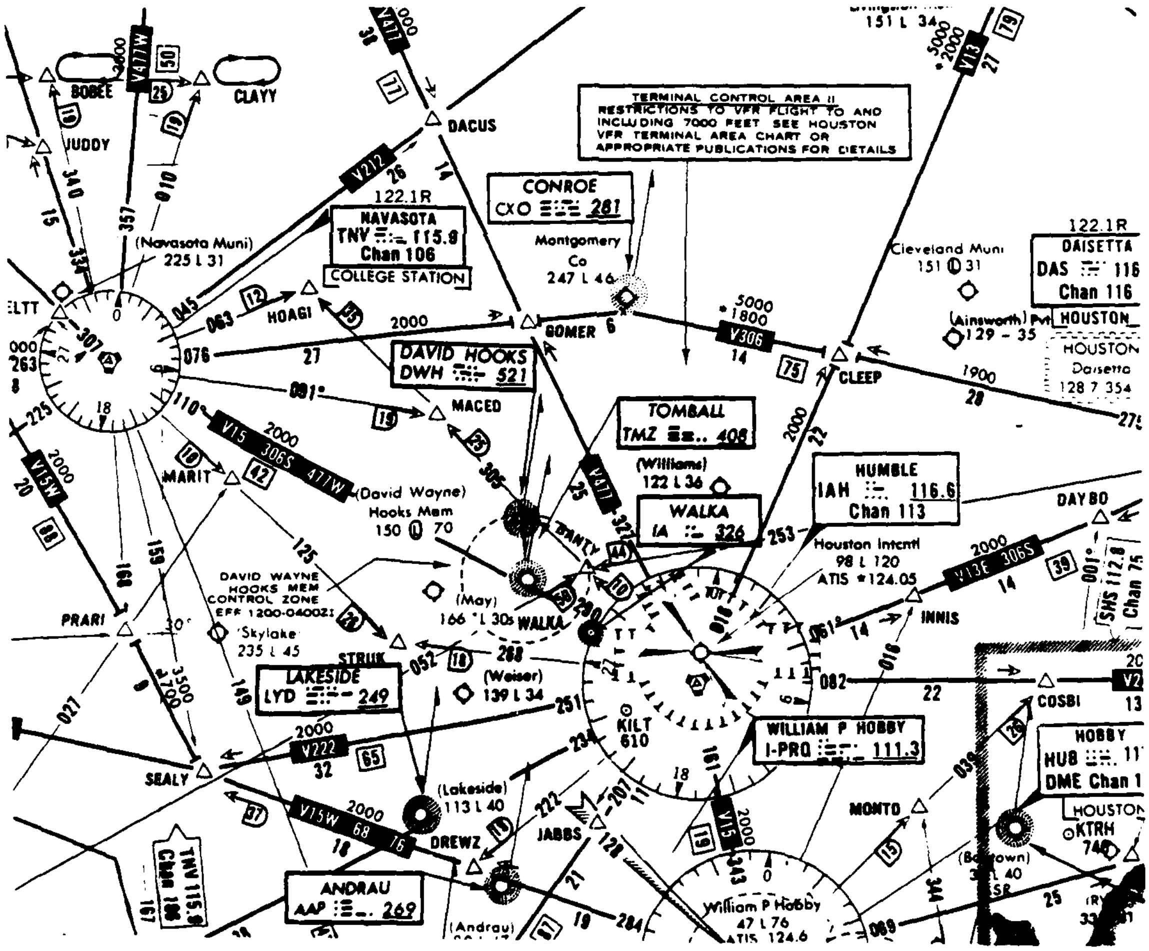


Figure 2.1-4. Low Altitude "Victor" Airway

Jet Routes

The high altitude or Jet airways are designated at or above 18,000 feet. The azimuth feature of the VHF Omnidirectional Range/Tactical Air navigation (VORTAC) is used for the establishment of the Jet route structure. The "J" is followed by a discrete number to form a specific airway, e.g., J60, J102, etc., as seen in Figure 2.1-5. The protected airspace along established jet airways is 4 nautical miles on either side of the route to a point 51 nautical miles from the Navigational Aid (NAVAID), then increasing in width on a 4.5 degree angle to a width of 10 nautical miles on each side of the route at a distance of 130 nautical miles from the NAVAID.

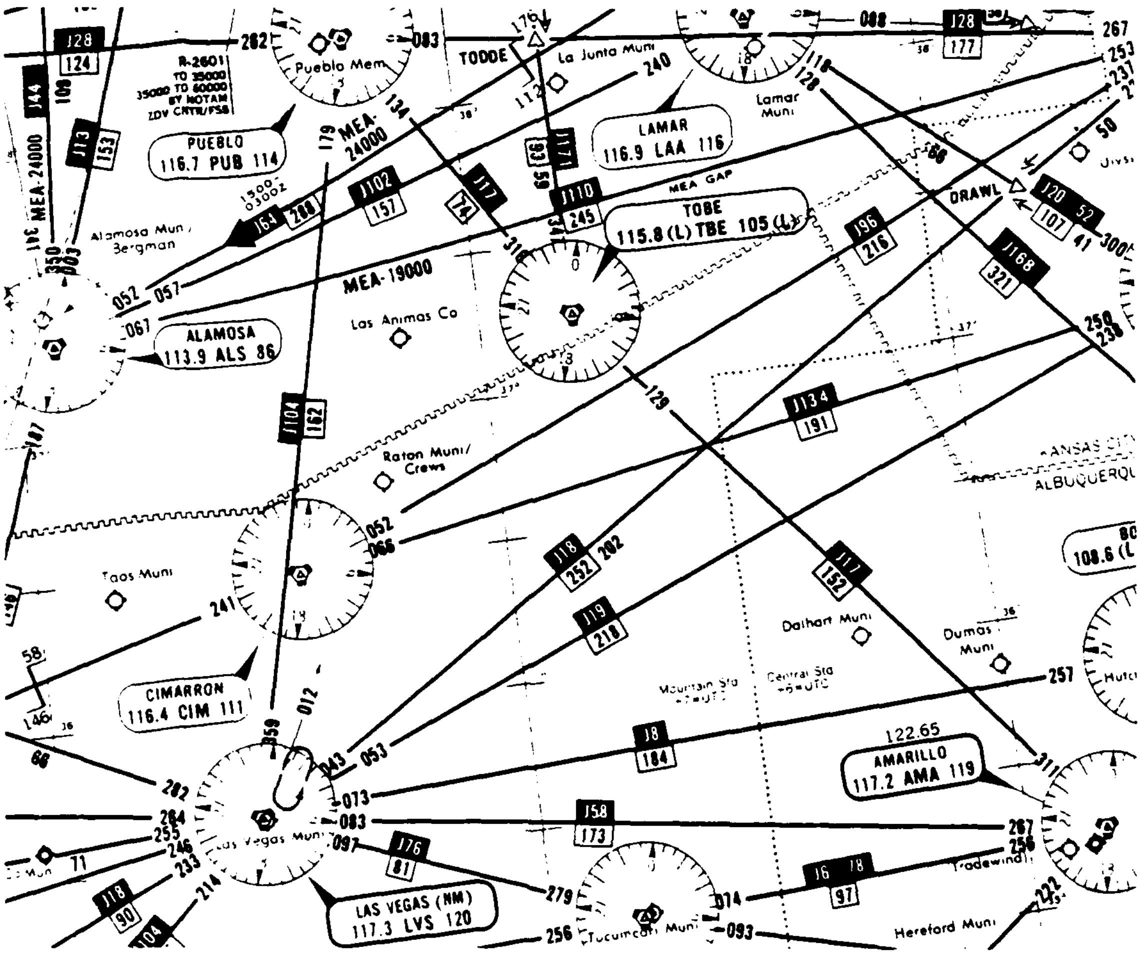


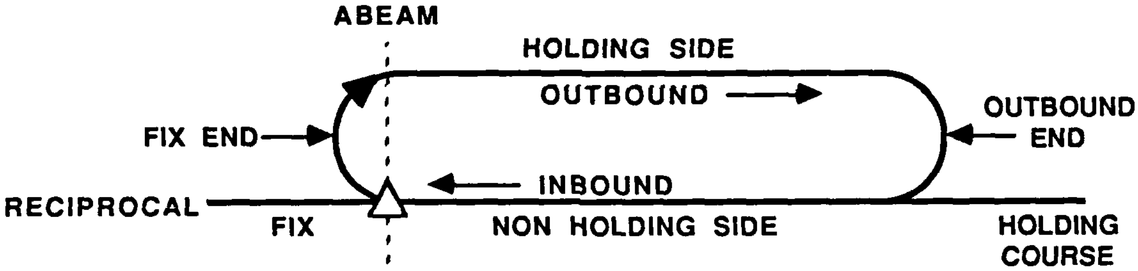
Figure 2.1-5. High Altitude "Jet" Airway

Holding Patterns

Normally, whenever a delay is required for an airborne aircraft, the controller may elect to clear the aircraft to hold at a fix where the aircraft will enter a holding pattern. The most commonly used holding patterns are depicted on en route and Standard Terminal Arrival (STAR) charts. Otherwise, the controller will issue the holding fix, direction of holding to or from the fix, and direction and duration of turns. See Figure 2.1-6 for an example of a hold at a fix. One of the uses of a holding pattern is to hold aircraft at common points in proximity to an airport awaiting weather improvements. Aircraft are held in a stack, separated by altitude, as shown in Figure 2.1-7. Holds also may be used for delaying en route aircraft to help regulate the flow of traffic.

Holding pattern airspace protection is based on the following procedures. They are the only procedures for entry and holding recommended by FAA.

(1) Descriptive Terms



(a) Standard Pattern: Right turns (illustrated)
(b) Nonstandard Pattern: Left turns

(2) Airspeeds (maximum)

(a) Propeller-driven -- 175K IAS
(b) Civil Turbojet

1. MHA through 6,000 feet -- 200K IAS
2. Above 6,000 feet through 14,000 feet -------------------------- 210K IAS
3. Above 14,000 feet --- 230K IAS

Figure 2.1-6. Holding Fix

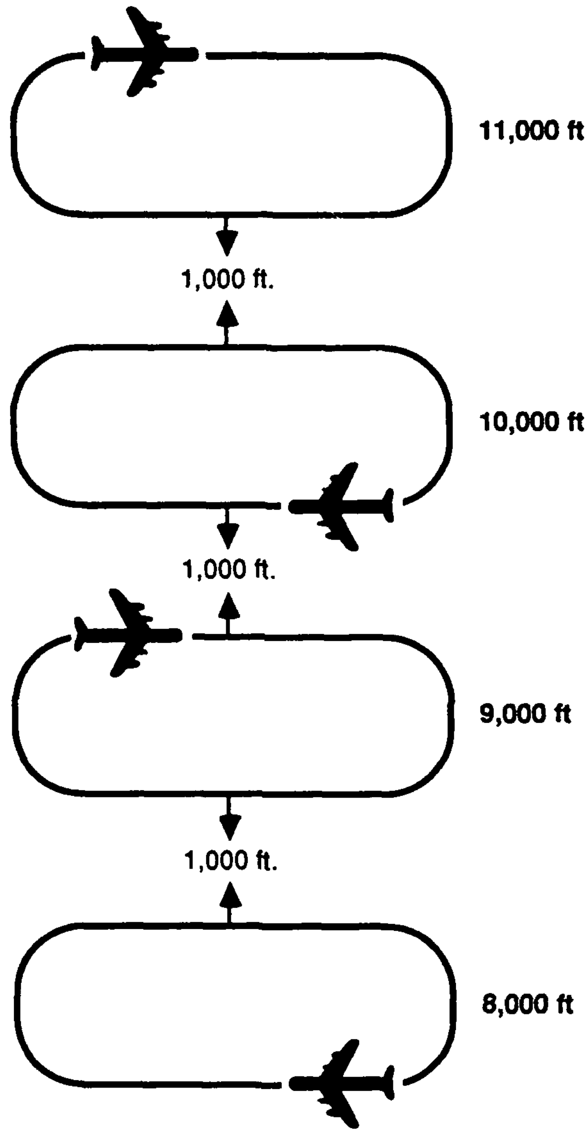


Figure 2.1-7. Holding Stack

Area Navigation (RNAV) and Other Systems

Area Navigation (RNAV) routes have been designated which allow properly equipped aircraft to fly directly from point to point without directly navigating toward or away from a navigational aid. These direct routes use waypoints, which are defined as bearing/distance fixes from specified NAVAIDs.

Omega is a network of eleven transmitting stations located throughout the world to provide signal coverage. These stations transmit a Very Low Frequency (VLF) signal that can be received at a distance of over one thousand miles.

Long Range Navigation (LORAN) is a navigation system by which hyperbolic lines of position are determined by measuring the difference in the time of reception of synchronized pulse signals from two fixed transmitters. A later version of LORAN, LORAN-C, is used in offshore areas where VOR/VORTAC is not available.

2.1.1.3 Navigation and Surveillance Facilities

The ground-to-air system comprises navigation and surveillance facilities. Navigational facilities provide guidance to aircraft. Surveillance facilities consist of remote sensors for ARTCCs, ATCTs, and TRACONs.

Navigation Capabilities

The present civil en route navigation system consists of VHF Omnidirectional Ranges (VORs), radio navigation facilities that provide point-to-point azimuth guidance. Distance information is obtained from Distance Measuring Equipment (DME). Military aircraft use the UHF Tactical Air Navigation (TACAN) system for azimuth guidance. Air routes may be thought of as line segments connecting the various navigation facilities. The non-directional beacon is a lower cost, lower capability alternative to the VOR station and is used where there is no VOR coverage. Beacons are used for en route guidance and fixes and as part of landing systems. See Table 2.1-2 for a description of en route Navigation Aids (NAVAIDs).

The Direction Finder (DF) is used to guide lost aircraft and for other emergencies. The aircraft's bearing is determined on the ground by using radio transmissions from the aircraft . The guidance information is then transmitted to the aircraft on a voice channel. The majority of the present DF systems are located at Flight Service Stations.

Surveillance Capabilities

Surveillance of the airspace is provided by two types of radar: primary radar and the radar beacon system, sometimes known as secondary radar. They are generally located at the same site. Primary radar relies only on signals reflected from aircraft. The beacon system receives reply signals transmitted from airborne electronic equipment called transponders. On aircraft equipped with altitude encoders, the transponder automatically transmits the plane's altitude. The beacon system is presently the main source of surveillance information used for air traffic control. Primary radar supplements the beacon system and gives weather information.

Table 2.˙-2. En Route Navigation Aids

Beacon	The Nondirectional Radio Beacon (NDB) transmits nondirectional signals that give relative bearing information to a station. When a radio beacon is used in conjunction with the Instrument Landing System (normally at the outer marker), it is a Compass Locator.
VHF Omnidirectional Range (VOR)	The VHF Omnidirectional Range provides a 360 degree signal for navigation. The accuracy of the VOR is excellent and it is generally within one degree of the course alignment. The VOR is one of the two mainstays of the airway structure.
Tactical Air Navigational (TACAN)	The Tactical Air Navigation, which is peculiar to military operations, transmits an Ultra High Frequency signal of both azimuth and distance information. It does not operate through conventional VOR equipment.
VHF Omnidirectional Range/Tactical Air Navigation (VORTAC)	The VHF Omnidirectional Range/Tactical Air Navigation consists of two components, VOR and TACAN. The VORTAC provides VOR azimuth, TACAN azimuth, and TACAN distance. It operates on more than one antenna system and incorporates more than one frequency but it is considered to be one navigational aid. The VORTAC is the other mainstay of the ATC airway route structure.
Distance Measuring Equipment (DME)	The Distance Measuring Equipment provides the distance signal at VOR. DME also can be used in an Instrument Landing System installation.

There are two types of primary radars. The en route system consists of long-range radar, while airport terminal radars are of shorter range. The long-range radar is called the Air Route Surveillance Radar (ARSR). The coverage normally extends to 200 miles. In some instances the ARSR enables a Center to provide arrival/departure radar service. There are some areas where long-range radars do not overlap. This occurs more frequently in the western and remote areas of the U.S. where mountainous terrain may block radar signals from the valleys and on the far side of the mountains. The Airport Surveillance Radar (ASR) provides coverage out to a maximum radius of 60 miles.

2.1.1.4 ARTCC Flight Plan Functions

Air Traffic Control (ATC) is a service provided by the FAA to promote the safe, orderly, and expeditious flow of air traffic. This subsection, and the three subsections which follow, describe the concepts and philosophy underlying ATC. This subsection is structured to provide the reader with a description of flight rules. The next subsection is a summary of separation standards and a discussion of techniques employed by controllers to maintain separation, followed by subsections on advisory and other services.

Flight Rules

Instrument Flight Rules (IFR) govern the procedures for conducting instrument flight. General ceiling and visibility conditions for Instrument Meteorological Conditions (IMC) apply. Visual Flight Rules (VFR) govern the procedures for conducting visual flight. The term VFR is also used to indicate Visual Meteorological Conditions (VMC) weather conditions. Before flying, pilots must determine, from weather briefings concerning the airspace within which they will be flying, whether they will be operating under VFR or IFR flight rules. A pilot may file IFR in VFR conditions. There are many subsets of VFR operation.

If operating under IFR, the pilot is provided separation from other aircraft operating under IFR. Separation is provided from special use airspace, and advisories are given on weather and other phenomena. If operating under VFR, the pilot may request and be provided with air traffic and weather advisory services, depending on controller workload.

Flight Plan Filing

For all IFR and certain VFR flights, the pilot introduces the aircraft into the ATC system by filing a flight plan. Normally, the flight plan is forwarded to the Air Route Traffic Control Center, since the Center is the pivotal facility for almost all IFR flight plans, even those flights that proceed under Tower en route control where the flight is handled by Approach Control at Terminals and never enters Center airspace. The reason for this is that the Center assigns a discrete beacon code, transmits the appropriate flight progress strips to Flight Data Entry and Printout (FDEP) equipment located at Terminal facilities, and transmits ARTS interface messages. This is done automatically, thus reducing manual input by controllers at the various facilities.

Military Base Operations (BASOPS) receive en route flight plans from military pilots and transmit them directly into the en route Center's computer via teletype. After the computer has processed the flight plan, it is transmitted to the controllers in the form of flight progress strips. Local training mission flight plans may be prefiled in a Center's computer system.

General aviation pilots normally file their flight plans, if needed, through the local Flight Service Station (FSS) for teletype transmission to a Center's computer. Towers, on occasion, may accept flight plans for entry into the system.

Flight plans for many air carrier operations are frequently prefiled in a Center's computer via the Stored Flight Plan (SFP) program. Another common method is to transmit the flight plan from the air carrier's operation room directly into the ARTCC computer via teletype. A less frequently used method is for the air carrier to call the Center, or call the local FSS for relay to the Center.

Flight Plan Clearance Request/Delivery

After the pilot has completed the ground check and is ready for IFR flight, a clearance will be requested from the Tower, if appropriate. In some instances where there is neither a Tower nor a Flight Service Station, the pilot may communicate directly with the Center or TRACON via an air-to- ground radio frequency, or the pilot may take off using VFR and contact the Center for a clearance.

Separation is assured by the issuance of controller instructions and ATC clearances. A clearance is a tactical action by the controller to prevent collision between known aircraft and is also authorization to proceed under specified traffic conditions within controlled airspace.

Clearance items may include:

- Aircraft identification or call sign
- Clearance limit
- Route of flight, including special procedures
- Altitude data in the order flown
- Holding instructions
- Radar heading
- Beacon code and transponder data
- Frequency or communications data
- Speed
- Release data and restrictions.

At an airport with a Tower, the clearance will be either pre-coordinated between the Center and the Tower in a Letter of Agreement, or the Tower will request a clearance from the appropriate sector within the Center. The Tower will generate a clearance for aircraft remaining in the terminal area. The clearance is normally to the destination airport and is subsequently issued to the pilot via the terminal clearance delivery position. Prior to the issuance of a clearance, the Center controller will examine the departure flight progress strip, with emphasis on the requested altitude and route versus other strips on aircraft that could be a factor. The controller will then issue clearances with additional instructions to ensure separation from other aircraft. The terminal controller will add any necessary restrictions to clear traffic in the terminal area.

The flight plan, which was in an inactive or proposed status, becomes active once the aircraft is airborne. The departure time is inserted into the en route computer system by either an automatic ARTS interface message or manually through the terminal FDEP equipment, or a controller keyboard entry into the en route computer system. The en route computer system will automatically post flight progress strips at a specified time prior to the calculated time over each fix

(navigational aid or airway intersection). The computer will also forward the flight plan data prior to the aircraft's arrival at the next adjacent Center, or at a specific time.

Flight Plan Amendments

The pilot may request to amend the flight plan at any time, whether it is active or inactive. If the flight plan is still inactive, an amendment message will be entered into the computer system by the FDEP terminal or the Center sector. If a route change will conflict with prescribed preferential routes (routes that have been preestablished for predominant traffic), the amendment may be rejected. Otherwise, new data will be stored in the computer. If the flight plan is active, coordination between controllers or facilities may be required before the change is approved and entered into the system. Once entered, the amended data replace the original data for all subsequent interfaces. Amended data are produced for all facilities and controllers that had already received the original flight plan data.

2.1.1.5 ARTCC Separation Functions: The Essence of Air Traffic Control

The essence of ATC is the application of approved separation standards as found in FAA Order 7110.65, Air Traffic Control [18]. This order prescribes the ATC procedure and phraseology (standard terminology and formatting rules for communicating with pilots) in providing ATC services. Oceanic separation standards are contained in FAA Order 7110.83, Oceanic Air Traffic Control [17].

Separation is provided by establishing approved longitudinal, lateral, or vertical distance between aircraft. Longitudinal separation is the spacing of aircraft at the same altitude by a minimum distance expressed in units of time or miles. Lateral separation is the spacing of aircraft at the same altitude by requiring operation on a different route or in a different geographical location. Vertical separation is established by assignment of different altitudes or flight levels. The following separation minima apply to domestic, but not oceanic, control.

Longitudinal Separation

Longitudinal non-radar separation is established by using minimum distance, time, speed, or a combination of items. The most common application of longitudinal separation is 10 minutes between aircraft.

The following are other examples of longitudinal separation, with some of the separation conditions omitted for brevity:

- 5 miles using Distance Measuring Equipment (DME) or 3 minutes when the leading aircraft is 44 knots faster

- 10 miles using DME or 5 minutes when the leading aircraft is 22 knots faster

- 10 miles using DME or 5 minutes when the leading aircraft is descending or the following aircraft is climbing

- 20 miles between aircraft using DME.

Lateral Separation

Lateral non-radar separation is established by route structures, with protected airspace that does not overlap, to keep aircraft at a particular altitude on different routes.

Lateral separation is established by one of the following methods:

- Clear aircraft on different airways or routes whose widths or protected airspace do not overlap
- Clear aircraft below 18,000 feet to proceed to and report over or hold at different geographical locations determined visually or by reference to navigational aids
- Clear aircraft to hold over different fixes whose holding pattern airspace areas do not overlap each other or other airspace to be protected
- Clear departing aircraft to fly specified headings that diverge by at least 45 degrees.

Vertical Separation

Vertical separation is established by assigning 1,000 feet between aircraft up to and including 29,000 feet (flight level 290, FL 290). Above FL 290 2,000 feet separation is required. A special VFR flight may be separated from an IFR flight while in a control zone by requiring the VFR flight to maintain special VFR conditions at or below an altitude which is at least 500 feet below any conflicting IFR traffic, but not below the minimum safe altitude prescribed in FAR 91.79 [24].

Radar Separation

Radar separation may be applied between aircraft by establishing at least a 3 mile separation between identified aircraft when they are at a flight level (FL) below 18,000 feet and fewer than 40 miles from the antenna. However, a 5 mile separation may be required by a facility directive if multiple radar sites are adapted in the computer for a specific area. Five miles separation is required if the aircraft are at or above 18,000 feet, or if they are 40 or more miles from the antenna. If the aircraft is at or above 60,000 feet (FL 600), then 10 miles separation is required. These minima are specified in FAA Order 7110.65, Air Traffic Control [18].

Radar separation may be reduced for aircraft departing from the same airport, depending on the runway alignment and direction flown after departure. As an example, radar separation may be one mile if aircraft are departing the same runway, or parallel runways less than 2,500 feet apart, if the aircraft courses diverge immediately after departure.

When non-radar separation standards are used, greater emphasis is placed upon the pre-planning of separation activity, since the distances required for longitudinal separation are much greater than normal radar separation. The aircraft's progress is maintained by position reports forwarded by the pilot and marked on the flight progress strip by the controller.

Adjacent Airspace

Aircraft are to be separated or provided a buffer from adjacent airspace unless coordinated with the controller of the adjacent airspace. Depending on the distance from the antenna, 3 nautical miles is normally required in the terminal area and 5 nautical miles is normally required in the en route environment. This also applies to tracking aircraft to the edge of the radar display.

Airspace Separation Techniques

Just as vehicular traffic moves on one-way streets, major airways sometimes are structured for one-way traffic flow, especially in major airport areas. Departing aircraft are normally tunnelled under arriving aircraft on one-way departure routes, through the low altitude Center sectors, and onto high altitude Jet routes, if appropriate.

Major airport areas have identified Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) routes, which are published for pilot and controller use in transitioning from the terminal and en route air route structures. In addition, the Host software employs logic to provide Preferential Departure/Arrival Routes (PAR, PDR, PDAR).

Through the use of the route structure, aircraft traveling in opposite directions are separated laterally, e.g., on different airways whose airspace does not overlap, while aircraft traveling in the same direction are separated vertically (by altitude) or longitudinally (by time or distance). Altitude assignments are made based upon the direction of flight.

Considerable thought is given to the airspace definition of a control sector or position. By proper pre-planning and alignment, coordination can be reduced and the traffic flow expedited. This is especially true in terminal transition areas.

Controller Separation Techniques

There are a variety of separation techniques available to the controller. Some are taught in training classes, in on-the-job training sessions, or learned from experience. The common separation techniques involve speed control, holding or 360 degree turns, and radar vectors including "S" turns.

Speed control is a valuable technique, especially appreciated by those concerned about air traffic efficiency. Speed control is frequently used in en route longitudinal separation by reducing or increasing the aircraft speed to provide compatibility with other traffic. It is also commonly used in transition areas for sequencing of arrival traffic, and is used extensively by feeder and final approach controllers.

Keeping aircraft in a holding pattern is frequently done when extensive delays are required, either due to weather or traffic congestion. In transition areas for landing aircraft, the leading aircraft descends to the lowest available altitude and subsequent aircraft are stacked at higher altitudes. En route aircraft are held at various holding points, with longitudinal separation maintained between crossing airways and other holding points. Unless landing is imminent, it often is more fuel efficient to hold aircraft at high altitudes, though other reasons may at times suggest the use of a different holding technique. In most holding situations a further clearance time

is issued to the pilot. If a short delay is necessary, a 360 degree turn, speed restrictions, or "S" turns may be used.

The most common separation technique used for climbing/descending aircraft and aircraft in transition areas is the radar vector. It is used extensively for aircraft in-trail. It is used until longitudinal, lateral, or vertical separation exists between aircraft. Radar vectors are frequently used to expedite traffic to and from airways and to assist the pilot in navigation. The use of different radars, radar techniques and presentation, and different radar separation standards will be a central issue in establishing common facilities, equipment, software, and procedures in the future Area Control Facility.

Non-Radar Separation Techniques

Greater emphasis is placed upon planning activities to effect separation in non-radar situations. During busy traffic periods, control becomes more rigid, with less emphasis than normal placed on pilot requests and more emphasis placed on scanning flight progress strips and verifying previously accomplished actions. Increased strip marking and the use of position reports are tools used by the controller to maintain the "picture" or situation assessment. Calculating and maintaining an awareness of aircraft ground speed becomes more important in en route non-radar situations. The controller will devote more attention to the previous fix time and the next reporting point estimated time than in a radar environment. During busy periods, the use of holding patterns becomes more prevalent because of the increased separation requirements. In general, pilot-controller communication must, of necessity, increase to a large degree, because the pilot must constantly relay position, verify present altitude, and pass on other control information.

2.1.1.6 ARTCC Advisory Service Functions

Controllers provide additional services such as traffic advisories, radar services, and weather advisories, to the extent possible, depending on higher priority duties.

Traffic Advisory

Traffic advisories are normally issued to all IFR aircraft, and to VFR aircraft on the controller's frequency, when their proximity may diminish to less than separation minima or when unknown traffic is observed and could be a factor. These services are not optional on the part of the controller, but rather are required, when the work situation permits.

Safety Alert

A safety alert is issued by a controller if the aircraft is judged to be in unsafe proximity to terrain, obstructions, or other aircraft.

Weather Advisory

Weather advisories are provided for as hazardous weather conditions not predicted in the area forecast thay may affect the operation of air traffic. These advisories are most frequently categorized as Significant Meteorological Information (SIGMET), Airman's Meteorological Information (AIRMET), or Center Weather Advisory (CWA).

Flight Following

Air traffic control facilities provide radar assistance to VFR aircraft based upon limitations of radar, volume of traffic, communications, and controller workload. These services include flight following and issuing of traffic information.

2.1.1.7 Other ARTCC Services

Controllers provide and solicit pilot reports (PIREPs) on weather information. This includes reports on strong frontal activity, squall lines, thunderstorms, icing, wind shear, and other pertinent data. These data are disseminated to other positions, facilities, and users as necessary or required.

Controllers provide advisory services on other phenomena such as chaff, gliders, hot air balloons, bird activity, parachutists, etc. To the extent possible, radar vectors are provided around any element that is considered a safety hazard. Controllers also provide radar navigation when requested or as necessary.

Controllers provide special VFR clearances within most control zones. An ATC clearance must be obtained prior to operating within a control zone when the weather is less clear than required for VFR flight. A VFR pilot may request and be given a clearance to enter, leave, or operate within most control zones under special VFR conditions, traffic permitting, and provided such flight will not delay IFR operations.

Oceanic Services

Oceanic Air Traffic Control services are provided in accordance with FAA Order 7110.83, Oceanic Air Traffic Control [17]. In addition to air traffic control, controllers provide Flight Information Service and Alerting Service. Flight Information Service consists of information on weather, vessels in the area, and updates concerning the status of navigational aids and airports. Alerting Service consists of collecting information regarding aircraft emergencies, forwarding that information to an appropriate Rescue Coordination Center, and coordinating with other control facilities.

2.1.1.8 ARTCC Positions

Within each Center's control room there are specified areas of operation or specialization. See Figure 2.1-8 for an example of a control room. An area of operation consists of a group of sectors requiring the services of several teams of controllers. The airspace within each specified area is divided into horizontal and vertical dimensions and designated as a sector. Several sectors (normally, six or more) make up an area. Each area team of controllers is supervised by an Area Supervisor.

Figure 2.1-8. Control Room Sector Configuration

Sectors are classified as radar, non-radar, or oceanic. They can be subclassified by altitude strata, such as high altitude and low altitude. The sector workstation is equipped with a flight progress board, radar Plan View Display (PVD), interphone and radio communication panels, and automation input/output devices and displays. Figure 2.1-9 shows a typical sector controller workstation. Figure 2.1-10 illustrates radar console operator panels. A plan view display of an air traffic situation can be seen in Figure 2.1-11.

Figure 2.1-9. Sector Layout

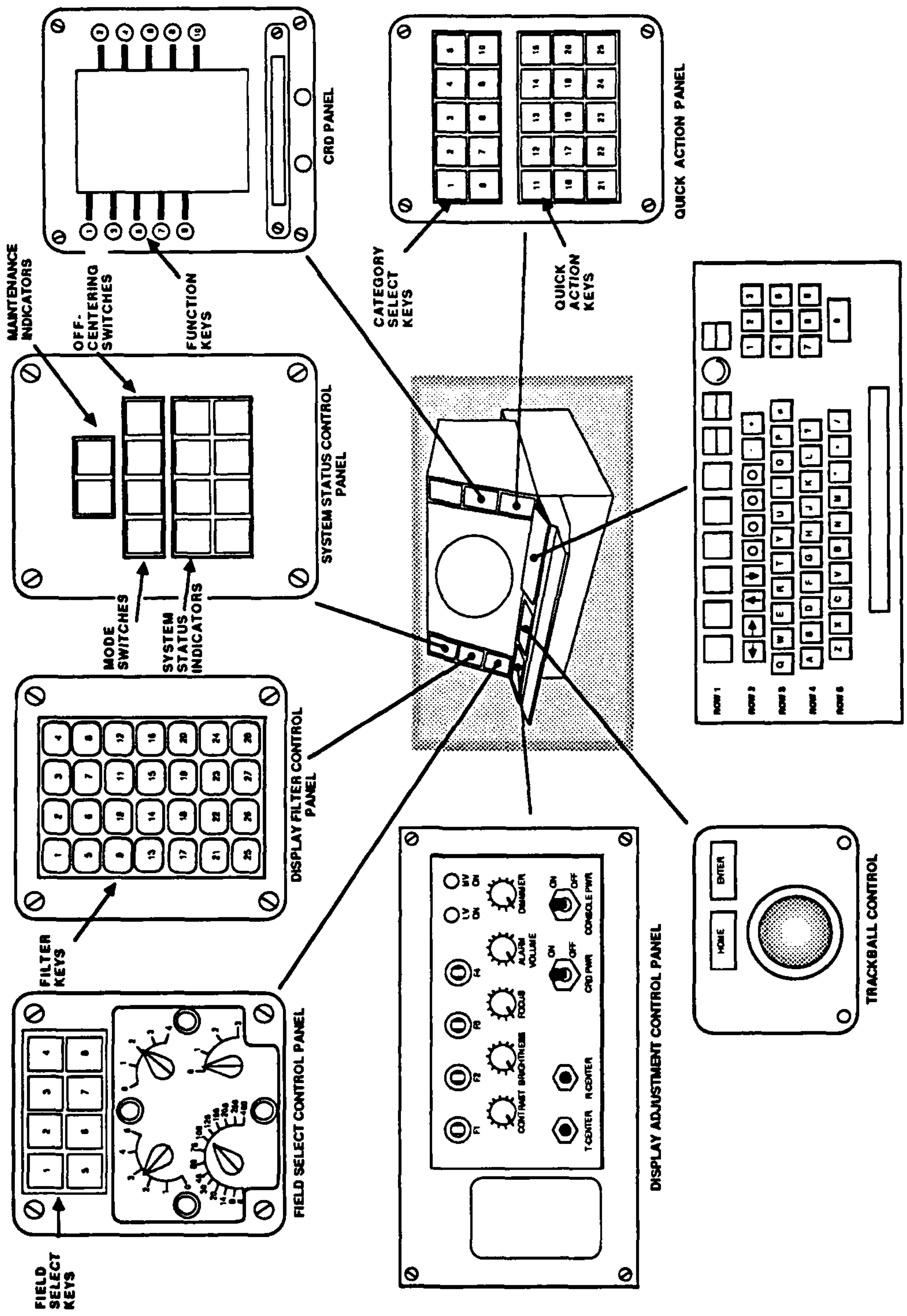
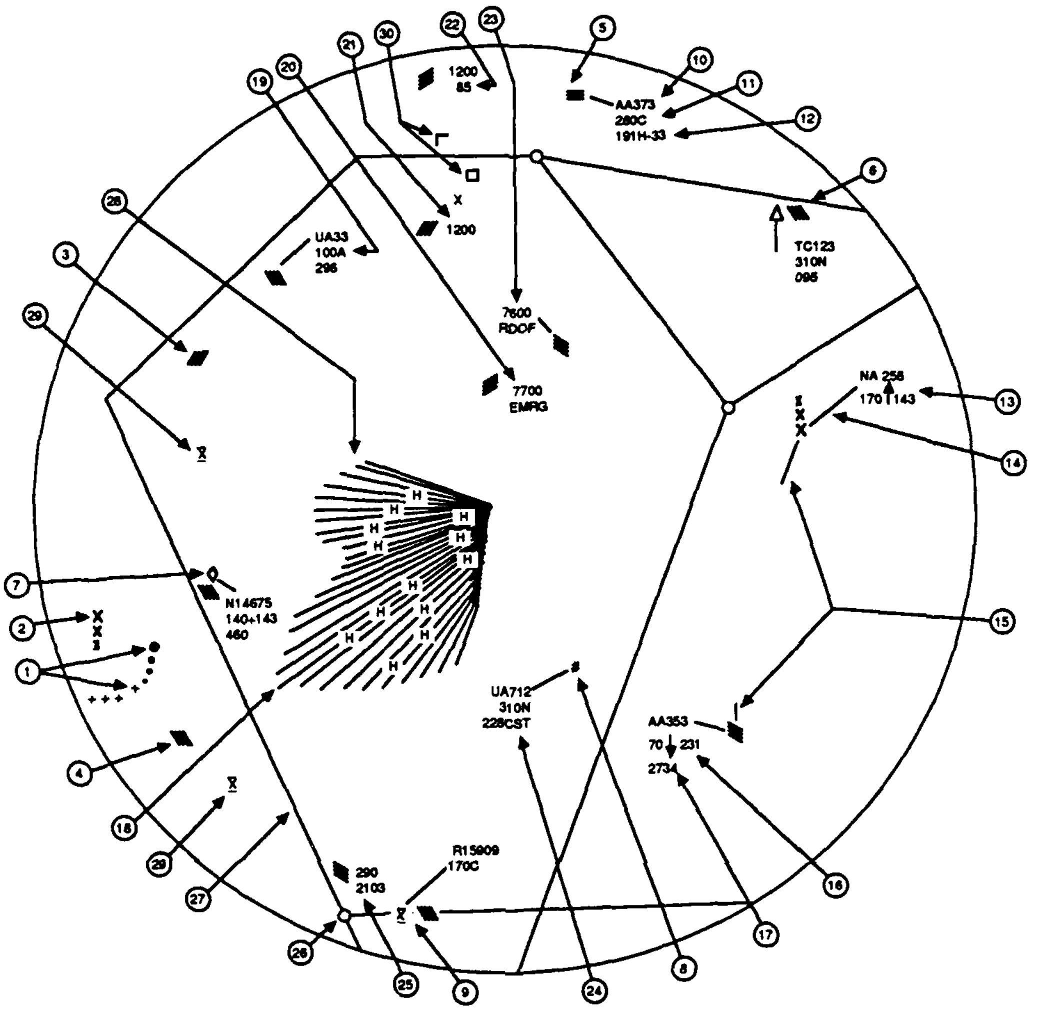


Figure 2.1-10. Radar Console Operator Panels



Target Symbols

1 Uncorrelated primary radar target + ●
2 *Correlated primary radar target x
3 Uncorrelated beacon target /
4 Correlated beacon target \
5 Identing beacon target
(*Correlated means the association of radar data with the computer projected track of an identified aircraft)

Position Symbols

6 Free track (No flight plan tracking) Δ
7 Flat track (flight plan tracking) ◊
8 Coast (Beacon target lost) #
9 Present Position Hold

Data Block Information

10 *Aircraft Identification
11 *Assigned Altitude FL280, mode C altitude same or within ±200' of assigned altitude
12 *Computer ID #191, Handoff is to Sector 33 (0-33 would mean handoff accepted) (*Nr's 10, 11, 12 constitute a "full data block")
13 Assigned altitude 17,000', aircraft is climbing, mode C readout was 14,300 when last beacon interrogation was received
14 Leader line connecting target symbol and data block
15 Track velocity and direction vector line (projected ahead of target)
16 Assigned altitude 7,000, aircraft is descending, last mode C readout (or last reported altitude was 100' above FL230)
17 Transponder code shows in full data block only when different than assigned code
18 Aircraft is 300' above assigned altitude
19 Reported altitude (no mode C readout) same as assigned. (An "N" would indicate no reported altitude)
20 Transponder set on emergency code 7700 (EMRG flashes to attract attention)
21 Transponder code 1200 (VFR) with no mode C
22 Code 1200 (VFR) with mode C and last altitude readout
23 Transponder set on Radio Failure code 7600, (RDOF flashes)
24 Computer ID #228, CST indicates target is in Coast status
25 Assigned altitude FL290, transponder code (These two items constitute a "limited data block")

Other Symbols

26 Navigation Aid
27 Airway or jet route
28 Outline of weather returns based on primary radar (H's represent areas of high density precipitation which might be thunderstorms. Radial lines indicate lower density precipitation)
29 Obstruction
30 Airports Major: □ , Small: ⌐

Figure 2.1-11. Plan View Display of Air Traffic Situation

The size and configuration of sectors are determined by traffic volume, traffic flow, types of aircraft, location and activity of underlying terminals, special operations and procedures, coordination requirements, radar and radio coverage, equipment limitations, and airway alignments. Center sectors normally are staffed with:

- A "D" controller (or manual controller) who is responsible for maintaining the flight strip board, issuing clearances over the interphone, and pre-planning control actions.

- An "R" radar controller who is responsible for issuing clearances by air-to-ground radio communications and insuring separation using radar equipment and procedures.

- An "RH" radar handoff controller who is responsible for initiating and accepting handoffs and other associated duties as described in facility operating procedures.

- An ATA (Air Traffic Assistant or assistant controller) who attends the flight strip printer and provides non-separation assistance to the "D" and "R" controllers.

The ATA may serve several sectors. At busy sectors, "RH" radar handoff controllers may be staffed. During light traffic periods the "D" and "R" positions may be combined. The "RH" controller is used during periods of heavy traffic conditions

There are many other positions within the Centers and FAA Headquarters which provide support and supervision to a Center's Air Traffic Control function and activities. These Center positions and other facilities are described in Table 2.1-3. Figure 2.1-12 shows the console used by one of these positions, the Airway Facilities Systems Engineer.

The FAA's Air Traffic Control Command Center (ATCCC) has overall responsibility for system-wide traffic flow management. This facility incorporates:

- Central Altitude Reservation Function (CARF), which is responsible for the coordination and approval of all military mission activity.

- Airport Reservation Function (ARF), responsible for aircraft reservations into specific airports and other special events (e.g., Indianapolis 500, Mardi Gras).

The ATCCC interfaces with Traffic Management Units in each ARTCC and with designated terminals. See Figure 2.1-13 for an example of a metering program on a Plan View Display (PVD).

2.1.2 Airport Traffic Control Tower

The Airport Traffic Control Tower (ATCT), or "Tower," is the image that comes to mind when people read or hear about air traffic control. Actually, the Tower is the newest member of the federal air traffic control system, having been incorporated into the federal system after the Airway Communications Station, commonly referred to as the Interstate Airway Communications (INSAC), and the Air Route Traffic Control Center (ARTCC).

Table 2.1-3. Supporting and Supervising Positions

Area Manager-In-Charge	Supervises the overall Air Traffic function in a Center's control room. Delegates authority to Area Supervisors to carry out assigned duties on a shift-to-shift basis. Provides overall facility management when the Facility Manager is not available.
Area Supervisor	Provides supervision and guidance to a team of controllers within a designated area, which normally consists of six sectors or more.
Traffic Management Coordinator	Responsible for administration of all Traffic Management functions in the Center control room, including flow control procedures, metering programs, en route spacing procedures, and traffic management programs administered by the Air Traffic Control Command Center. See Figure 2.1-13 for an example of a metering program on the PVD.
Flight Data Communications Specialist	Responsible for receiving and entering teletype messages. Also responsible for making computer entries when corrections to flight are necessary, and for entering surface weather observations as required.
Supervisory Flight Data Communications Specialist	Supervises the Flight Data Communications function.
Weather Coordinator	Responsible for the collection and dissemination of pertinent aviation weather data. Provides the shift briefings on weather impact as it may apply to traffic movement and timely and accurate coordination with the Traffic Management Unit personnel.
Airway Facilities System Engineer	Responsible for certification and monitoring of all systems associated with the NAS system at a specific Center. These duties include scheduling and coordination of all routine maintenance with air traffic control personnel. Air traffic supervisory personnel report all unsatisfactory equipment status to Airway Facilities. Figure 2.1-12 shows the System Engineer's console.

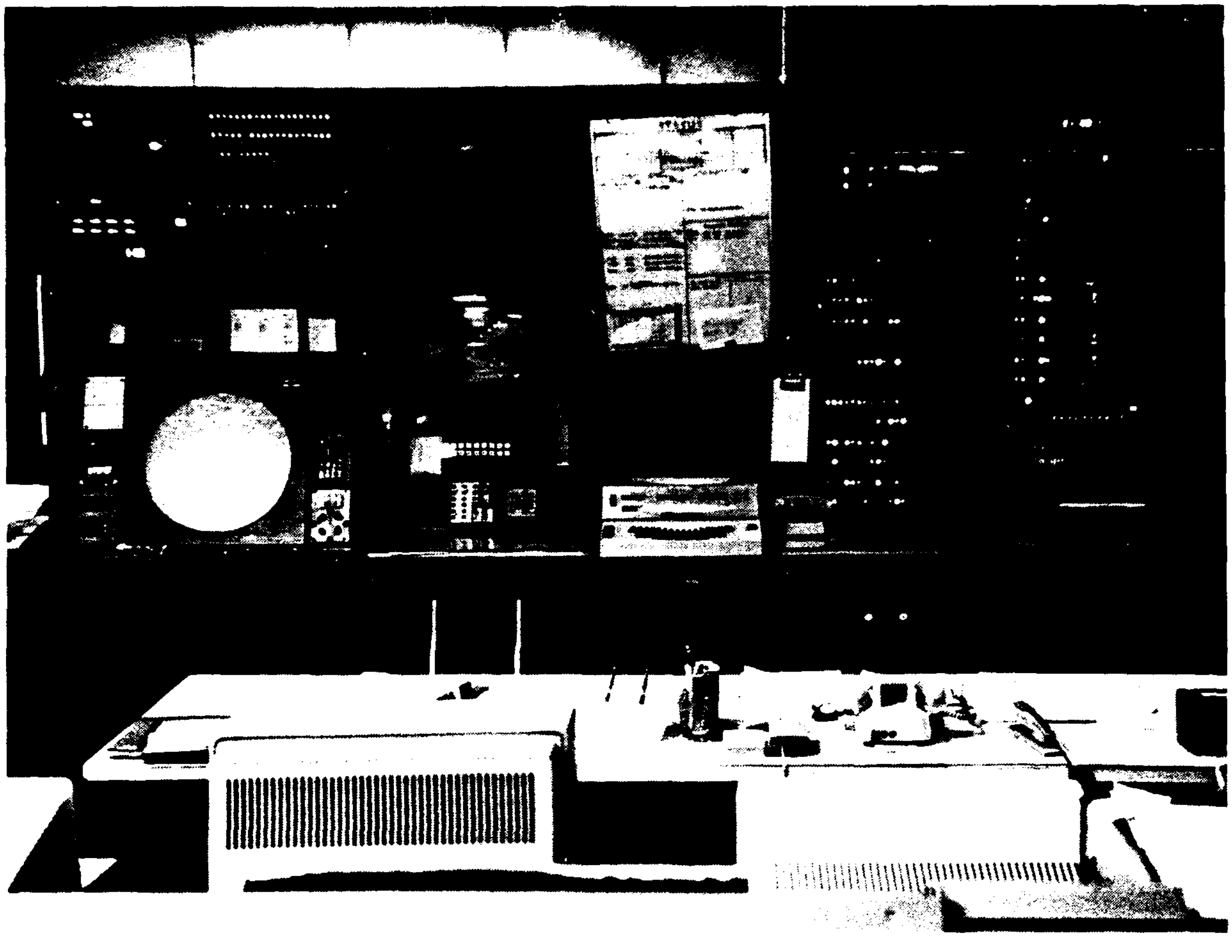


Figure 2.1-12. Airway Facilities Systems Engineer Console

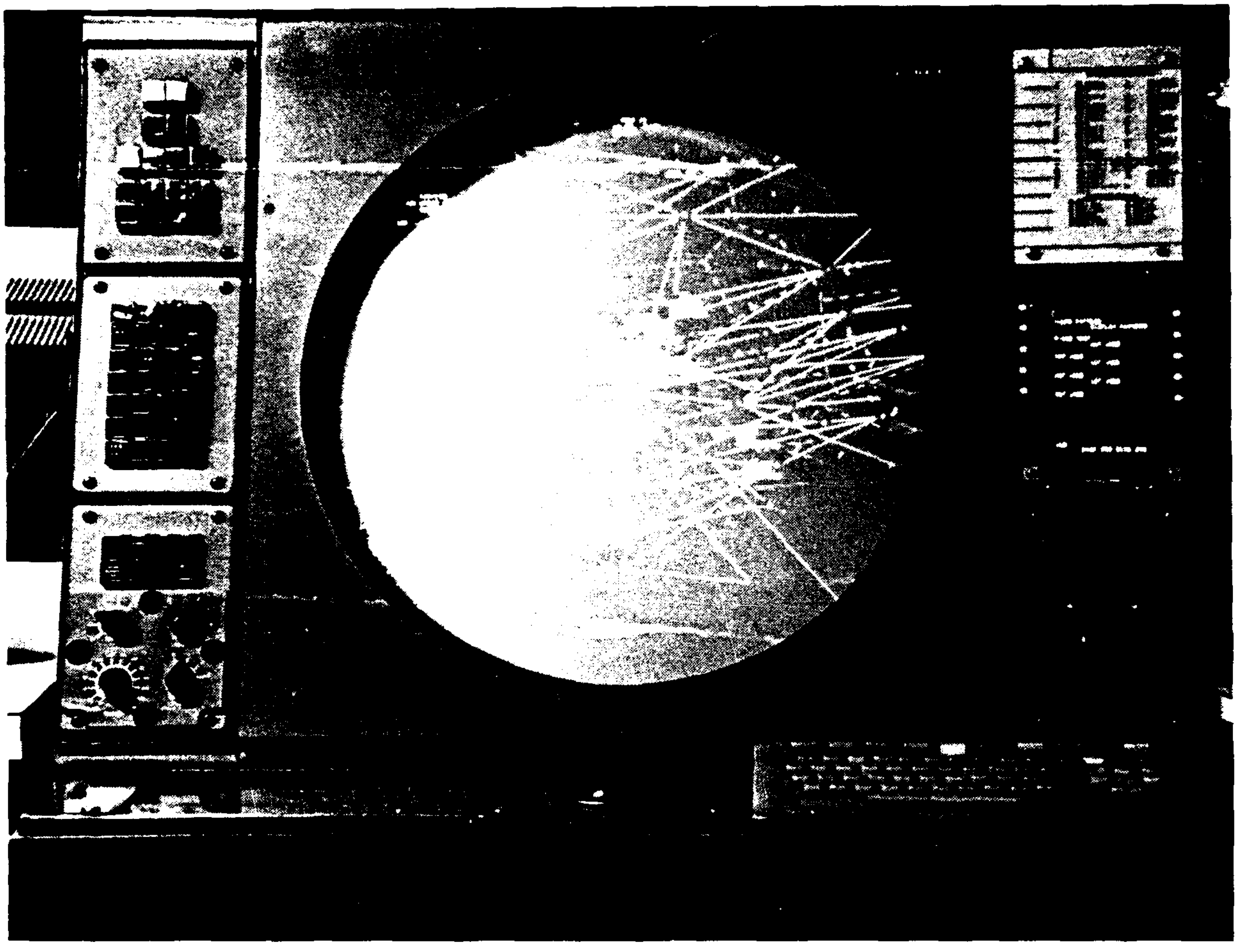


Figure 2.1-13. Metering Plan View Display

2.1.2.1 ATCT Development

Although all Tower controllers were required to be federally certificated in 1937, it was not until the advent of World War II that the Civil Aeronautics Authority (predecessor of the Federal Aviation Agency) began assuming control of the Towers. For a while there was a mixture of municipal, federal, and military Towers.

Although the runway/taxiway layout at an airport has a major impact on the controllers' ability to move aircraft, equipment improvements such as radar and automation have significantly contributed to the primarily visual environment of the Tower controllers. Improvements in navigation aids are also significant tools, especially at the larger facilities. But despite new equipment, Tower controllers are very dependent on direct observation in the conduct of their work.

The objective of the next system must be to integrate the Tower controllers' perceptual world (eyes and ears) with the improvements in navigation, radar, and automation. This includes weather detection and alerting systems.

2.1.2.2 ATCT Functions

The Tower controller provides for airport traffic control services. These services are provided to aircraft in the Airport Traffic Area and to aircraft and vehicles on the airport movement areas. Movement of aircraft or vehicles on non-movement areas, normally associated with gates and ramps, is the responsibility of the pilot, aircraft operator, or airport management.

Associated with these services are operation of the airport lighting, arresting systems (arresting gear-barriers) for the military, and runway selection. Tower controllers provide spacing and sequencing for touch-and-go, stop-and-go, or low approach, in addition to full stop landings. Departure separation and ground delays, applied to aircraft affected by traffic management restrictions, are the responsibility of the Tower controllers.

In addition to normal weather data provided to the pilot concerning visibility, ceiling, and wind, the controllers will alert pilots to runway conditions, low level wind shear alerts, as appropriate, and other safety alerts and observed abnormalities.

Tower controllers will also issue long range IFR departure clearances as specified in a letter of agreement with the ARTCC and will issue departure Terminal Radar Service Area (TRSA) and Terminal Control Area (TCA) clearances when delegated by the TRACON.

If IFR departure delays are in effect, the Tower will hold aircraft either at the gate or at a designated area on the airport that is commonly referred to as the "penalty box." If VFR arrival traffic must be held, the aircraft will be instructed to hold over an easily recognizable geographic feature.

Tower Types and Levels

Airport Traffic Control Towers use radar, if so equipped, and non-radar procedures to provide services to arrivals, departures, and flights transiting their airspace. An ATCT may be collocated with a Terminal Radar Approach Control (TRACON or TRACAB). There are five levels of

terminal facilities, with Level 1 having the least operations count and Level 5 having the greatest operations count. However, Level 4 and Level 5 facilities always include a radar approach control function. An ATCT without radar approach control cannot be higher than a Level 3.

Tower Airspace

No aircraft may be flown within an Airport Traffic Area except for the purpose of landing at, or taking off from, an airport within the area specified as an Airport Traffic Area, although aircraft may be authorized to transition through the area. The Airport Traffic Area generally extends to 3,000 feet above the elevation of an airport and to a horizontal radius of 5 miles. Authorization is required by Air Traffic Control to operate within this area.

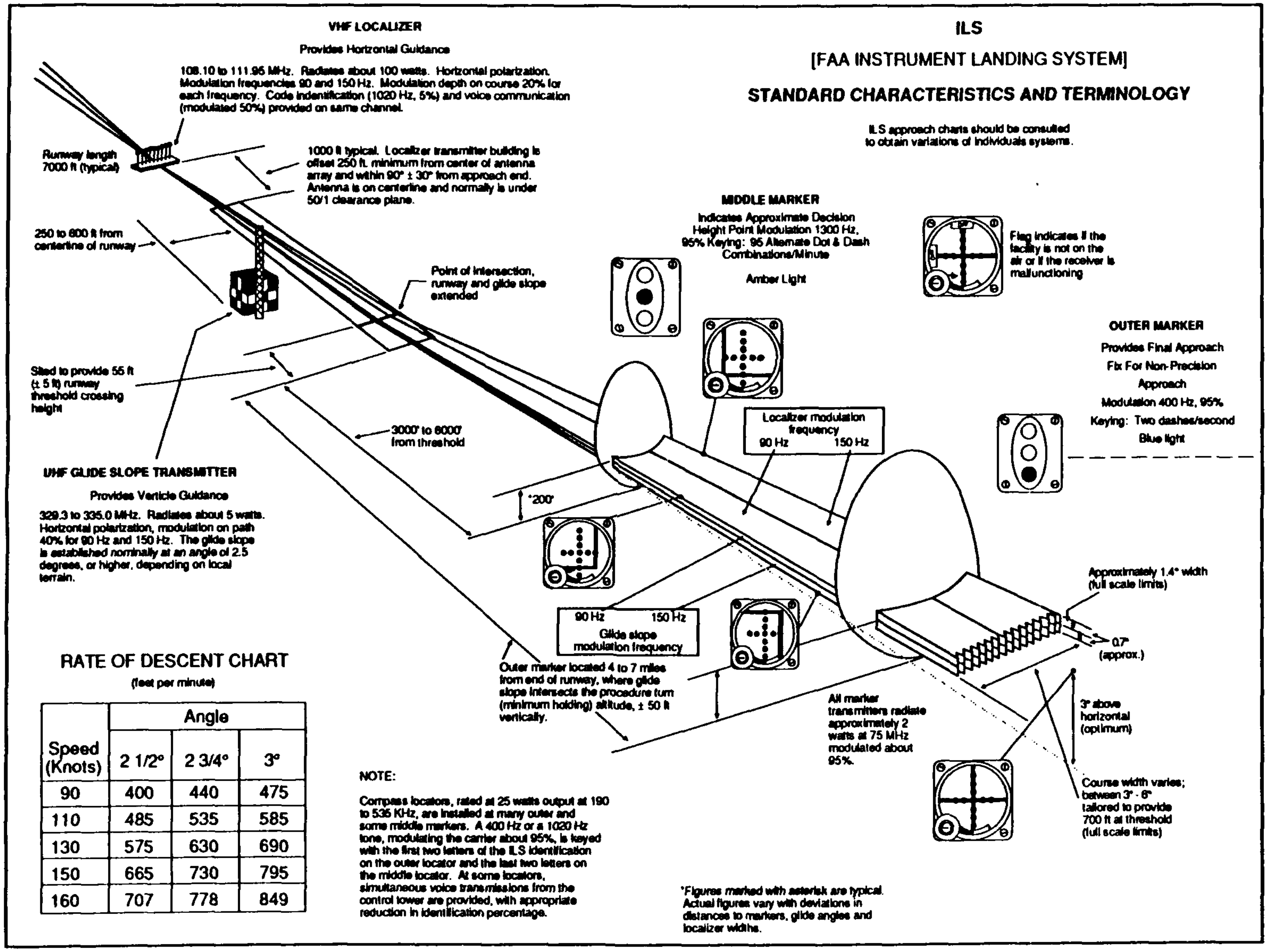
2.1.2.3 Tower Equipment

The basic equipment for Towers currently consists of control desks or consoles, communications panels, weather instruments and displays, radar (television monitor) displays, flight progress strips and holders or pads, navigation aid and airport lighting monitors and controls, Automatic Terminal Information Service (ATIS) recorders, and automation input/output equipment on-line to the overlying ARTCC. There may be many different configurations and types of equipment, and not all Terminals have all of the above equipment. Some Towers may have unique equipment items, such as a fuel cut-off switch, which belongs to airport management and is not directly related to ATC.

The Instrument Landing System (ILS) is the present primary airport precision approach and landing system. It uses both azimuth and elevation guidance from a ground facility, as well as marker beacons and compass locators which enable equipped aircraft to fly by instruments along the approach path to the runway. Non-precision approach with azimuth guidance only is available at some airports using the localizer portion of an ILS, VOR, or beacon. See Figure 2.1-14 for an example of an ILS.

The Microwave Landing System (MLS) is a replacement for the ILS and is currently being installed at many facilities. The MLS provides significant navigation improvement over the ILS and eliminates siting problems encountered by the ILS. The MLS provides range information in addition to azimuth and elevation guidance.

The VHF Omnidirectional Range (VOR) is a radio station range that provides point-to-point azimuth guidance for 360 degrees. Distance information may be added from Distance Measuring Equipment (DME). Military aircraft may use the Ultra High Frequency (UHF) tactical air navigation system called TACAN. The non-directional beacon is a lower cost, lower capability alternative to the VOR and is used where there is no VOR coverage. Beacons also are used as part of the landing system.



Speed (Knots)	Angle 2 1/2°	2 3/4°	3°
90	400	440	475
110	485	535	585
130	575	630	690
150	665	730	795
160	707	778	849

Figure 2.1-14. Instrument Landing System

In the tower cab, radar is presented on a television monitor display called the Bright Radar Indicator Tower Equipment (BRITE). This display can be viewed under relatively high ambient lighting conditions. A BRITE display is depicted in Figure 2.1-15. If alphanumeric data from an ARTS are displayed, the subsystem is referred to as the BRITE Alphanumeric Subsystem (BANS). BRITE or BANS may be transmitted to non-collocated Towers by microwave. The BRITE radar scan converter system is being upgraded to provide for Digital BRITE (D-BRITE) equipment. D-BRITE provides for sharper radar target and map images than the BRITE and is compatible with the ARTS.

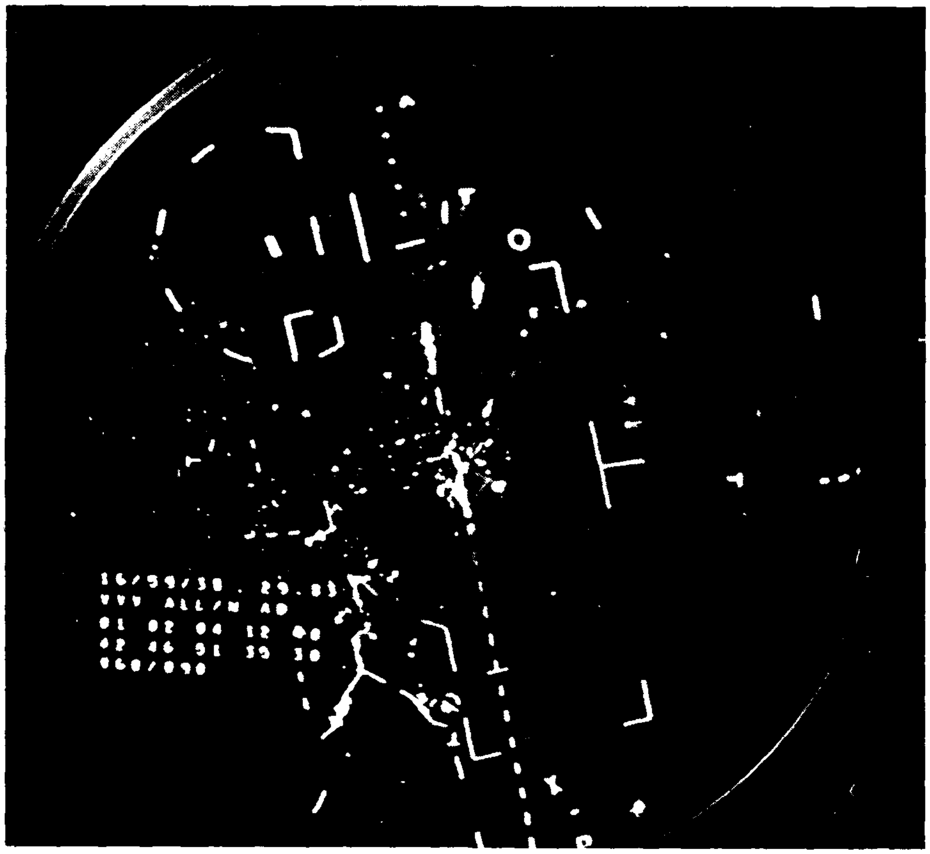


Figure 2.1-15. Bright Radar Indicator Tower Equipment (BRITE)

Flight data in the form of flight progress strips are printed on Flight Data Entry and Printout (FDEP) printers. The strips are produced by the en route Host computer in the ARTCC. Flight plans and flight plan amendments may be entered on an associated keyboard. There is usually one FDEP keyboard and one printer, plus a connected spare printer, in each tower cab. An FDEP is depicted in Figure 2.1-16. Flight strips of interest to each controller are maintained in flight progress bays, or on a hard rubber mat at the position, where they can be easily accessed and organized as the controller prefers. See Figure 2.1-17 for flight strips on a rubber mat and Figure 2.1-18 for an example of flight progress strips. This system is being replaced by the electronic Flight Data Input/Output (FDIO) subsystem.

Figure 2.1-16. Flight Data Entry and Printout (FDEP) Printer

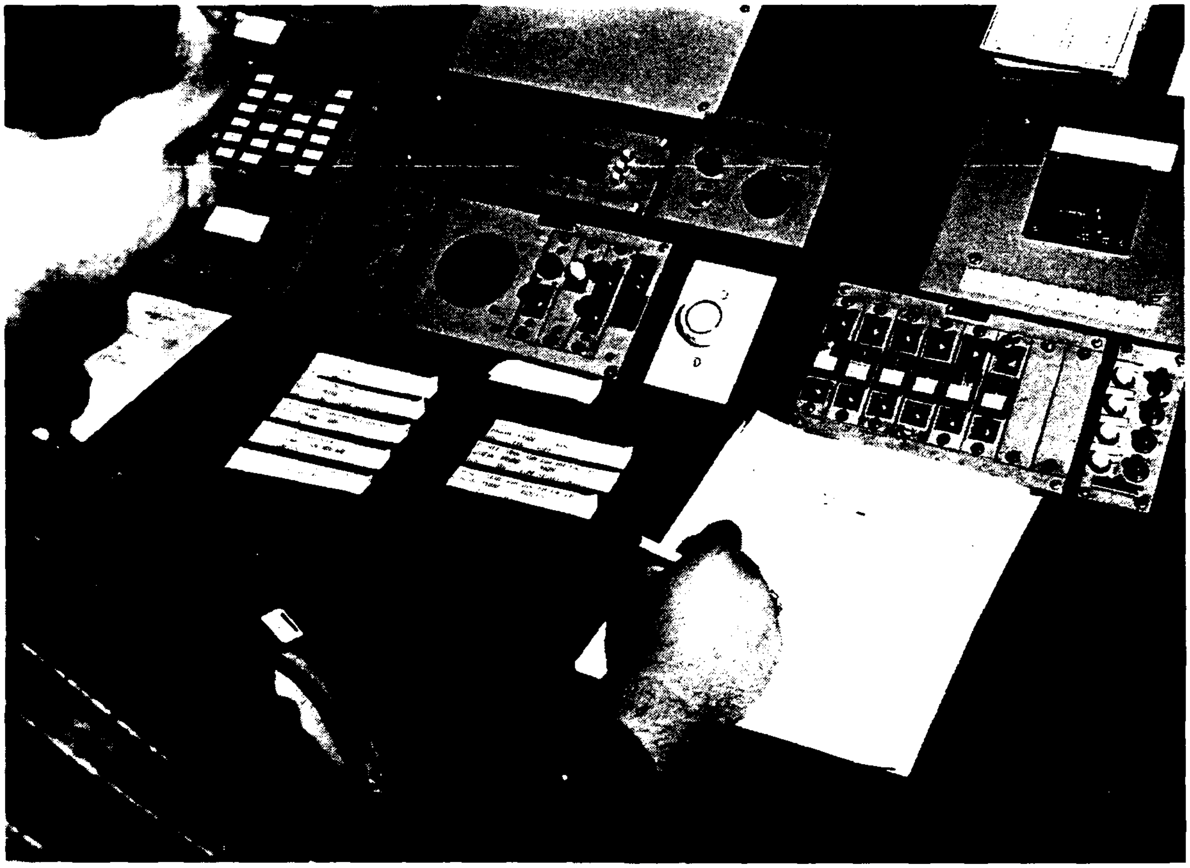


Figure 2.1-17. Flight Strips on Rubber Mat

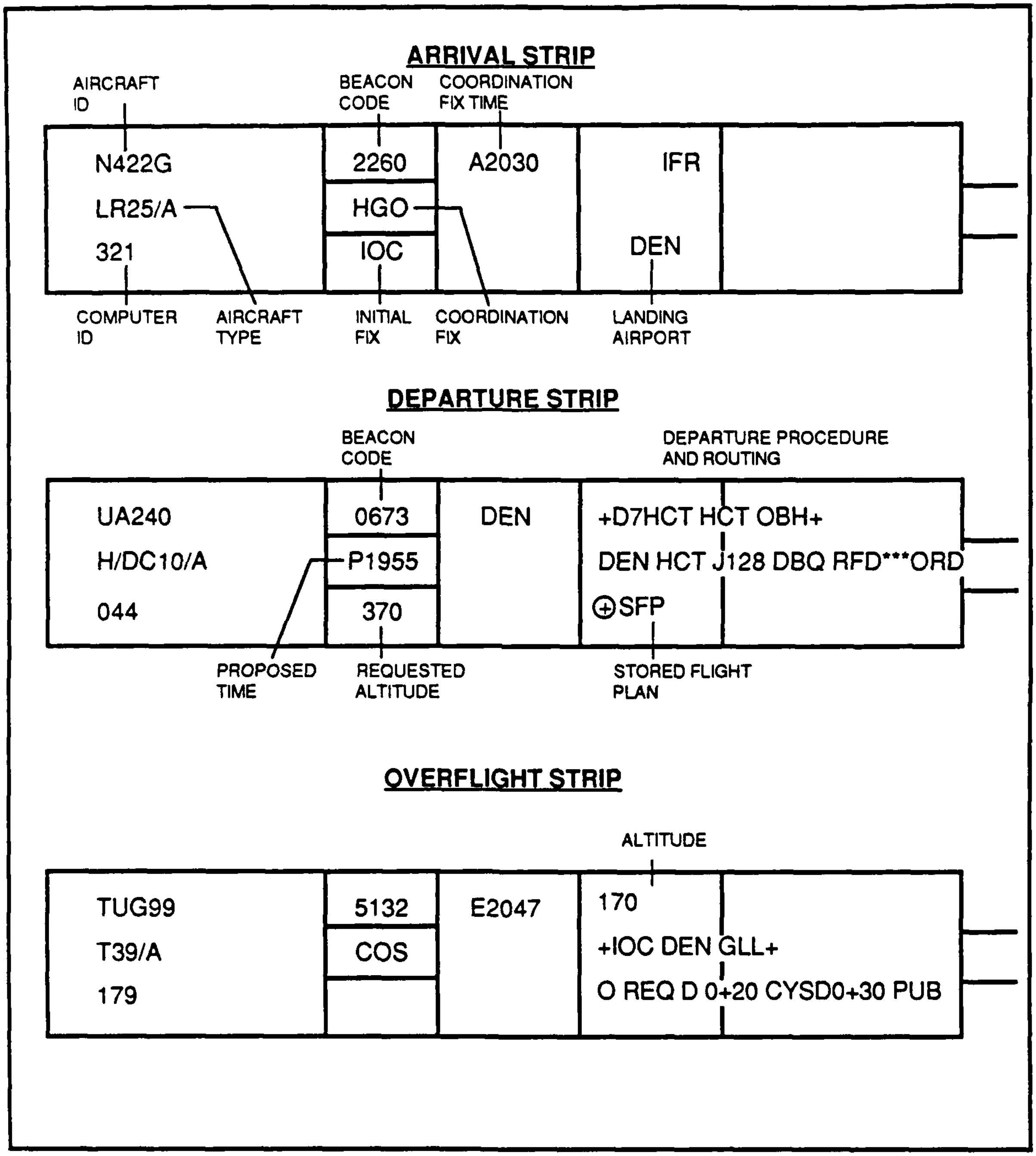


Figure 2.1-18. FDEP Strips

Some of the larger Towers are equipped with Airport Surface Detection Equipment (ASDE). This is a specifically designed radar used to detect and display all principal features on the surface of an airport, including aircraft and vehicular traffic. It is used to augment visual observation by controllers of aircraft and vehicular movements on runways and taxiways. It is especially helpful in areas that are obscured from the controller's vision or during periods of reduced visibility.

All Towers are equipped with radio and telephone communications. Radio communications are air/ground VHF and UHF transmitters and receivers. Ground-to-ground telephone communications connect the Tower with the ARTCC, Flight Service Station, and other airport offices. Figure 2.1-19 shows the current communications panel. All Towers are equipped with light guns, which are used to signal aircraft or vehicles that do not have or have lost radio capability. Figure 2.1-20 shows a typical light gun.

There are many types of airport lighting aids. See Table 2.1-4 for a description of the airport lighting aids and Table 2.1-5 for a description of the approach lighting. Figure 2.1-21 shows an airport lighting panel. Airport lighting equipment is normally owned by the local airport management.

Controllers may record and monitor information on the Automatic Terminal Information Service (ATIS). Its purpose is to improve controller effectiveness and to relieve frequency congestion by automating the repetitive broadcast of recorded non-control but essential information relating to airport weather, runway conditions, and other pertinent data.

Weather observations may be supported by specialized weather equipment or taken automatically. The equipment may be quite sophisticated or may be a simple visual observation of a geographic feature. At many locations weather observations are relayed to the Tower by the National Weather Service. Low Level Wind Shear Alert System (LLWAS) equipment is shown in Figure 2.1-22.

Figures 2.1-23, 2.1-24, 2.1-25, and 2.1-26 provide an example equipment layout of the Flight Data, Clearance Delivery, Ground Control, and Local Control positions, respectively.

2.1.2.4 ATCT Positions

At present, normal controller checkout of facility certification starts with the Flight Data position, goes through the Clearance Delivery and Ground Control positions, and culminates in the Local Control position. This section describes the positions and provides a short description of their operation.

- *Clearance Delivery/Flight Data Controller* duties, which often are combined into one operational position, include the insertion of flight plans and amendments into the computer system, providing for the distribution of flight plan data to appropriate positions, issuing initial long-range clearances, entering and updating the ATIS, and, if necessary, coordinating with the ARTCC on clearances.

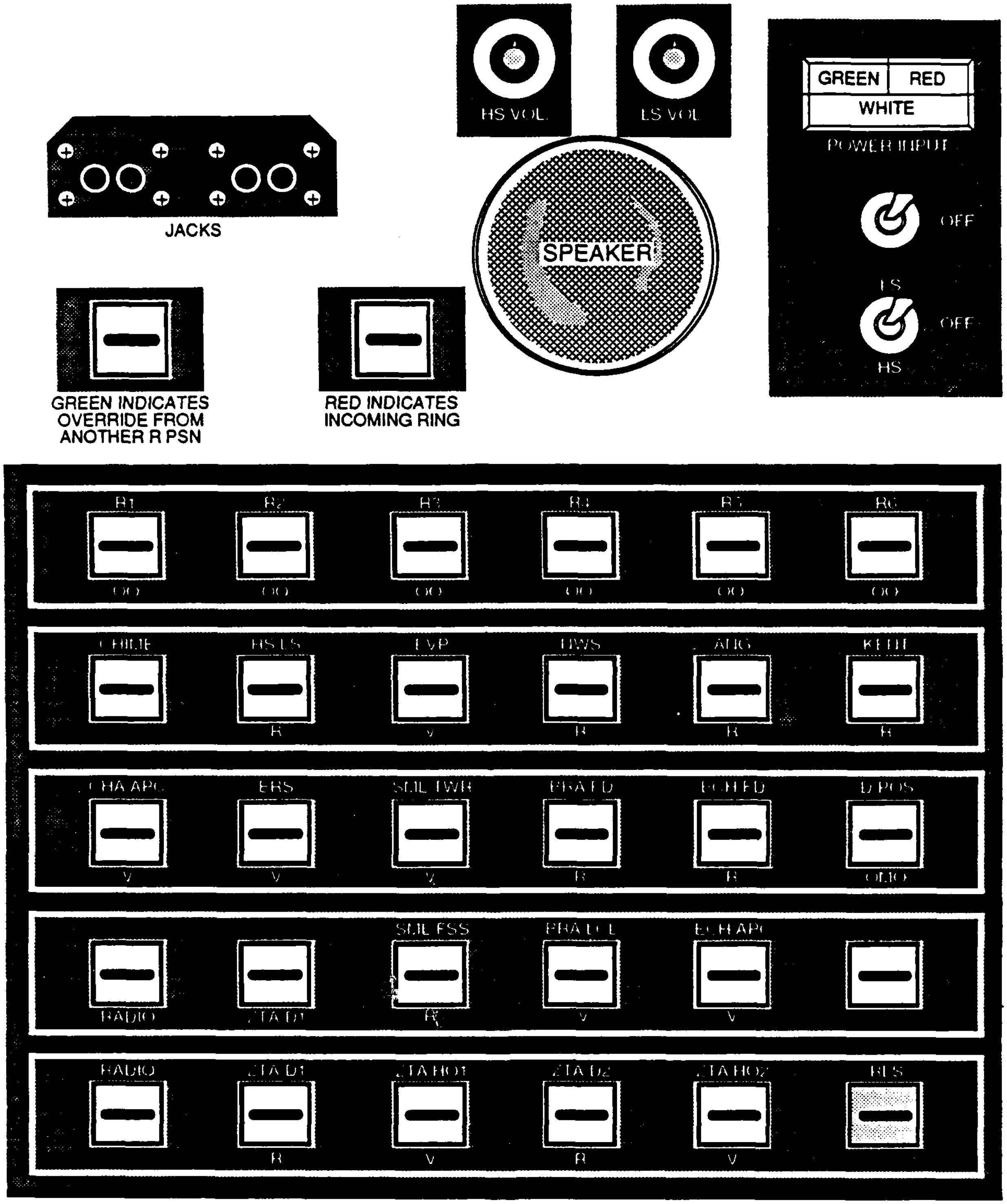


Figure 2.1-19. Communication Panel

Figure 2.1-20. Light Gun

Table 2.1-4. Airport Lighting	
RUNWAY EDGE LIGHTS	Lights having a prescribed angle of emission to define the lateral limits of a runway. Runway lights are uniformly spaced at intervals of approximately 200 feet. The intensity may be controlled or preset.
TOUCHDOWN ZONE LIGHTING	Two rows of transverse light bars located symmetrically about the runway centerline normally at 100-foot intervals.
RUNWAY CENTERLINE LIGHTING	Flush centerline lights spaced at 50-foot intervals beginning 75 feet from the landing threshold and extending to within 75 feet of the opposite end of the runway.
THRESHOLD LIGHTS	Fixed green lights arranged symmetrically left and right of the runway centerline, identifying the runway threshold.
RUNWAY END IDENTIFIER LIGHTS	Two synchronized flashing lights, one on each side of the runway threshold, which provide rapid and positive identification of the approach end of a particular runway.
BOUNDARY LIGHTS	Lights defining the perimeter of an airport or landing area.

Table 2.1- 5. Approach Lighting	
ALSF-I	Approach Light System with sequenced Flashing lights in ILS category I configuration.
ALSF-II	Approach Light System with sequenced Flashing lights in ILS category II configuration.
SSALF	Simplified Short Appoach Light System with sequenced Flashing lights.
SSALR	Simplified Short Appoach Light System with Runway alignment indicator lights.
MALSF	Medium intensity Approach Light System with sequenced Flashing lights.
MALSR	Medium intensity Approach Light System with Runway alignment indicator lights.
LDIN	Sequenced flashing Lead-In lights.
RAIL	Runway Alignment Indicator Lights.
ODALS	Omnidirectional Approach Lighting System consisting of seven omnidirectional flashing lights located in the approach area of a nonprecision runway.
VASI	Visual Approach Slope Indicator is an airport lighting facility providing vertical visual approach slope guidance to aircraft during approach to landing by radiating a directional pattern of high intensity red and white focused light beams. Red/white indicate on glide path; white/white indicate above glide path; and red/red indicate below glide path. Some airports have three-bar VASIs which provide two visual glide paths to the same runway.

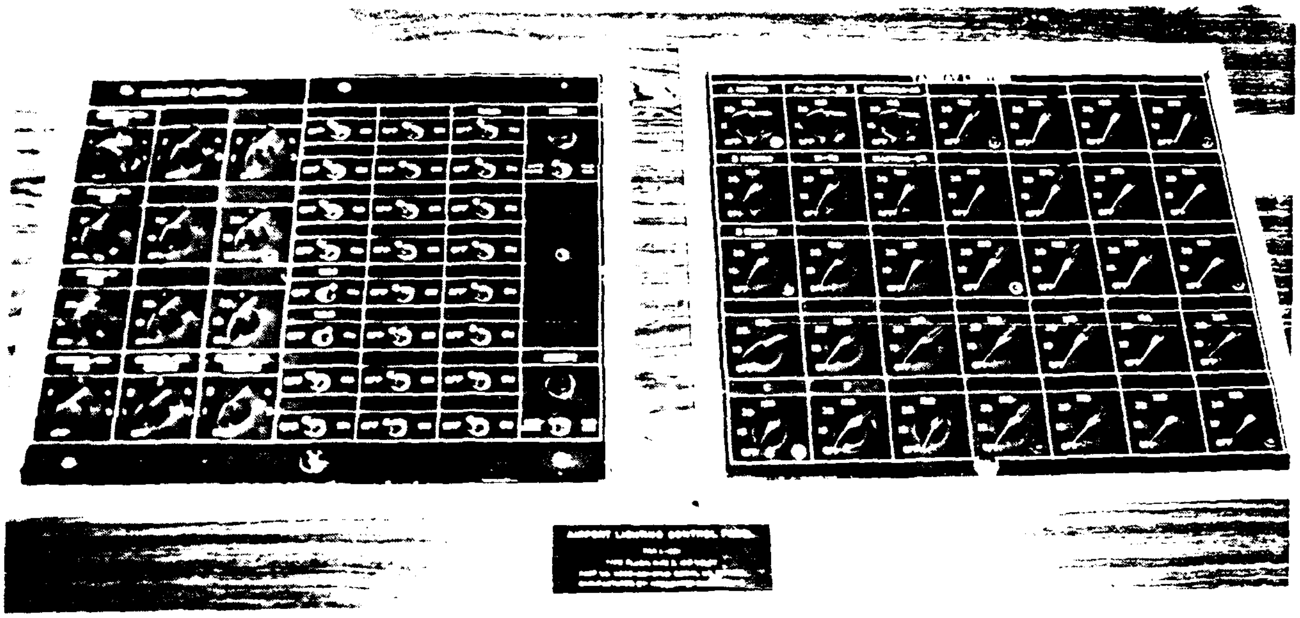


Figure 2-21. Airport Lighting Control Panel

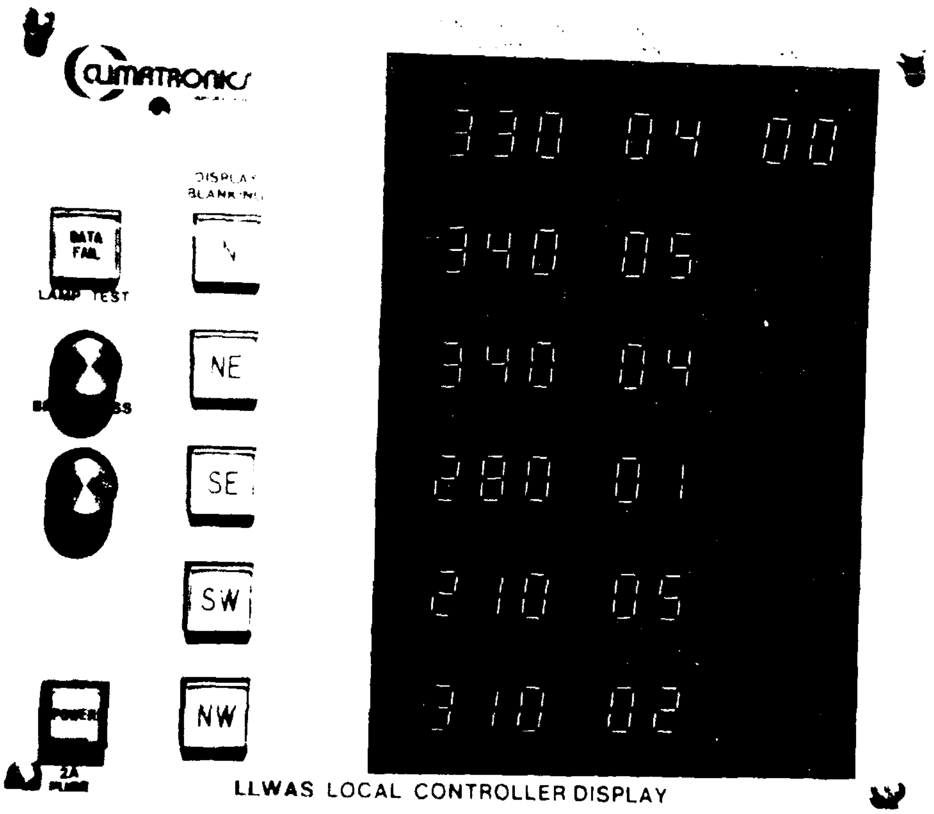
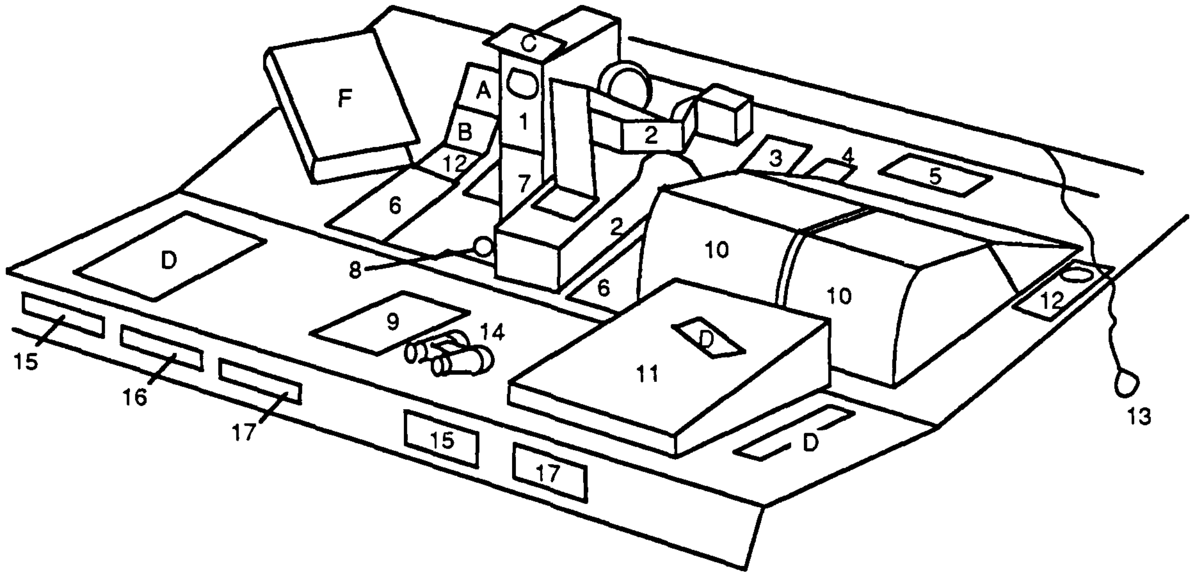


Figure 2-22. Low Level Windshear Alert System



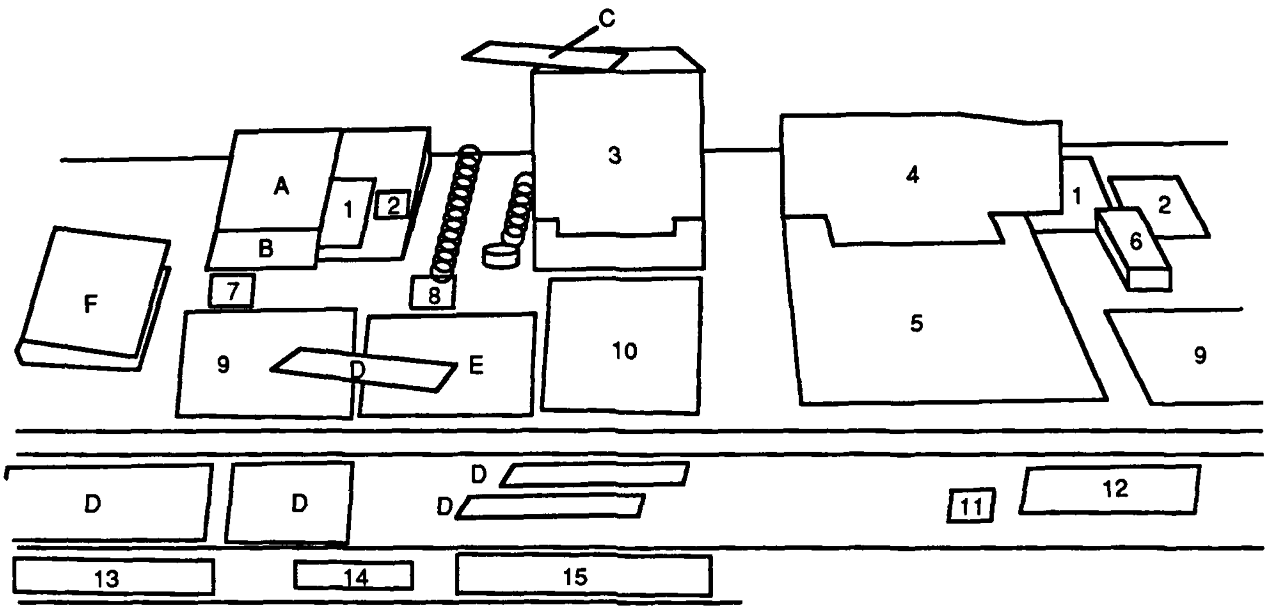
DEVICES

1. CONRAC MONITOR
2. ELECTROWRITER & PAPER TAKE-UP
3. TELCO SPEAKER
4. DIGITAL CLOCK
5. FDEP SELECTOR SWITCH
6. TELCO DIAL AND KEYPACK
7. ATIS RECORDING CONTROLS
8. FAA COMMUNICATIONS PANEL
9. ALPHANUMERIC KEYBOARD
10. FDEP PRINTERS
11. FDEP KEYBOARD
12. LIGHT RHEOSTAT
13. SHADE CORD
14. BINOCULARS
15. TELCO JACKS
16. FAA RADIO JACK
17. FLIGHT STRIP BIN

PAPER

A. POSITION LOG
B. POSITION RELIEF BRIEFING GUIDE
C. ATIS RECORDING FORMAT
D. FLIGHT STRIPS
E. OUTBOUND & INBOUND ROUTING CHART
F. FLIGHT DATA POSITION BINDER

Figure 2.1-23. Flight Data Position



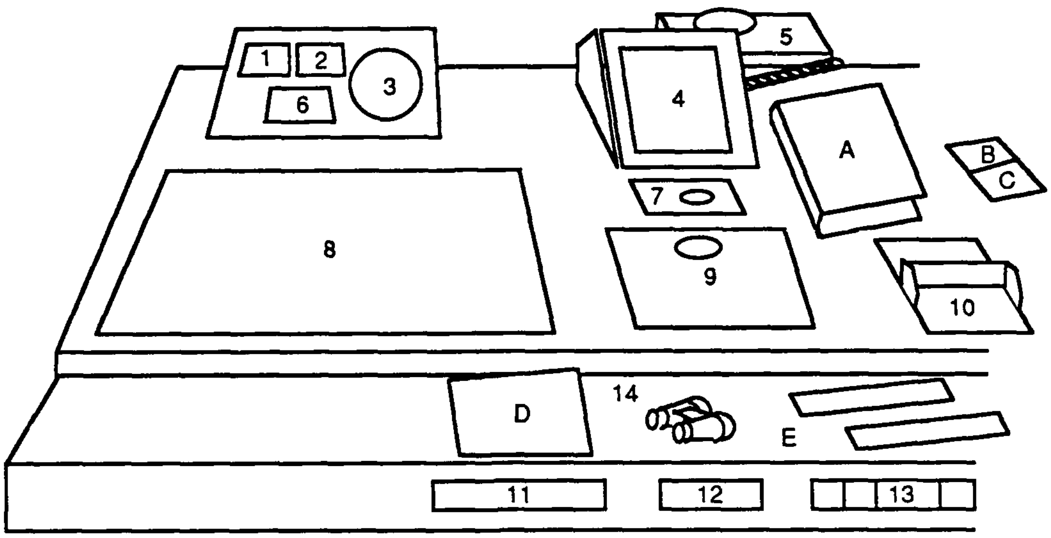
DEVICES

1. TELCO SPEAKER
2. DIGITAL CLOCK
3. CONRAC MONITOR
4. ELECTROWRITER PAPER TAKE-UP
5. ELECTROWRITER
6. ELECTROWRITER SELECTOR SWITCHES
7. LIGHT RHEOSTAT
8. ATIS RECORDING CONTROLS
9. TELCO DIAL & KEYPACK
10. FAA COMMUNICATIONS PANEL
11. ARTS ENTER BUTTON, PEM STICK
12. ALPHANUMERIC KEYBOARD
13. TELCO JACKS
14. FAA RADIO JACK
15. FLIGHT STRIP BIN

PAPER

A. POSITION LOG
B. POSITION RELIEF BRIEFING GUIDE
C. ATIS RECORDING FORMAT
D. FLIGHT STRIPS
E. OUTBOUND & INBOUND ROUTING CHART
F. CLEARANCE DELIVERY POSITION BINDER

Figure 2.1-24. Clearance Delivery Position



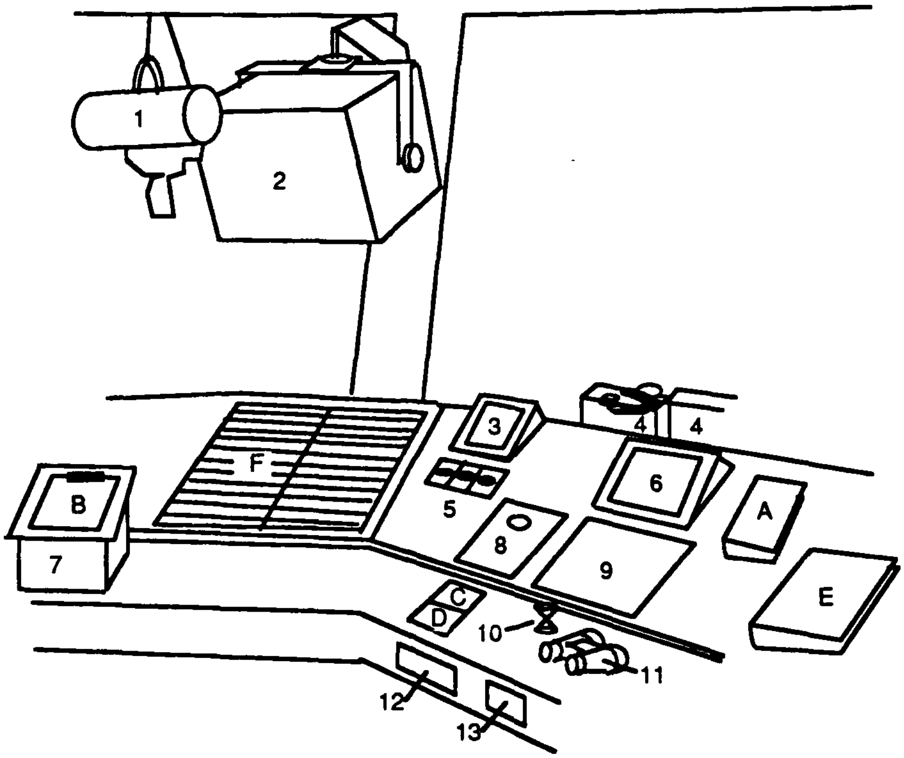
DEVICES

1. WIND DIRECTION INDICATOR
2. WIND SPEED INDICATOR
3. ANALOG ALTIMETER
4. TELCO SPEAKER
5. BACKUP VHF TRANSCEIVER
6. DIGITAL CLOCK
7. LIGHT RHEOSTAT
8. FIELD LIGHTING CONTROL PANEL
9. TELCO DIAL AND KEYPACK
10. FAA COMMUNICATIONS PANEL
11. TELCO JACKS
12. FAA RADIO JACKS
13. FLIGHT STRIP BIN
14. BINOCULARS

PAPER

A. GROUND CONTROL POSITION BINDER
B. POSITION LOG
C. POSITION RELIEF BRIEFING GUIDE
D. SCRATCH PAD
E. FLIGHT STRIPS

Figure 2.1-25. Ground Control Position



DEVICES

1. LIGHT GUN
2. BANS RADAR DISPLAY
3. TELCO SPEAKERS
4. BACKUP VHF TRANSCEIVERS
5. LIGHT RHEOSTATS
6. RVR PANEL
7. PODIUM
8. TELCO DIAL & KEYPACK
9. FAA COMMUNICATIONS PANEL
10. THREE - MINUTE TIMER
11. BINOCULARS
12. TELCO JACKS
13. FAA RADIO JACK

PAPER

A. REFERENCE NOTEBOOK
B. HOURLY TRAFFIC COUNT
C. POSITION LOG
D. POSITION RELIEF BRIEFING GUIDE
E. LOCAL CONTROL POSITION BINDER
F. FLIGHT STRIP BAY & STRIPS

Figure 2.1-26. Local Control Position

- *Ground Controller* duties are to provide aircraft/vehicle taxi instructions on the airport movement area exclusive of the active runways, coordinating as required on crossing or using the active runways. Taxi information may include pushback/powerback clearances from the gate, instructions to/from the airport movement area and the ramp/gate areas, and sequence arrangement for departure aircraft. Coordination may be required between multiple Ground and Local Controllers for ground movement of vehicles and aircraft.

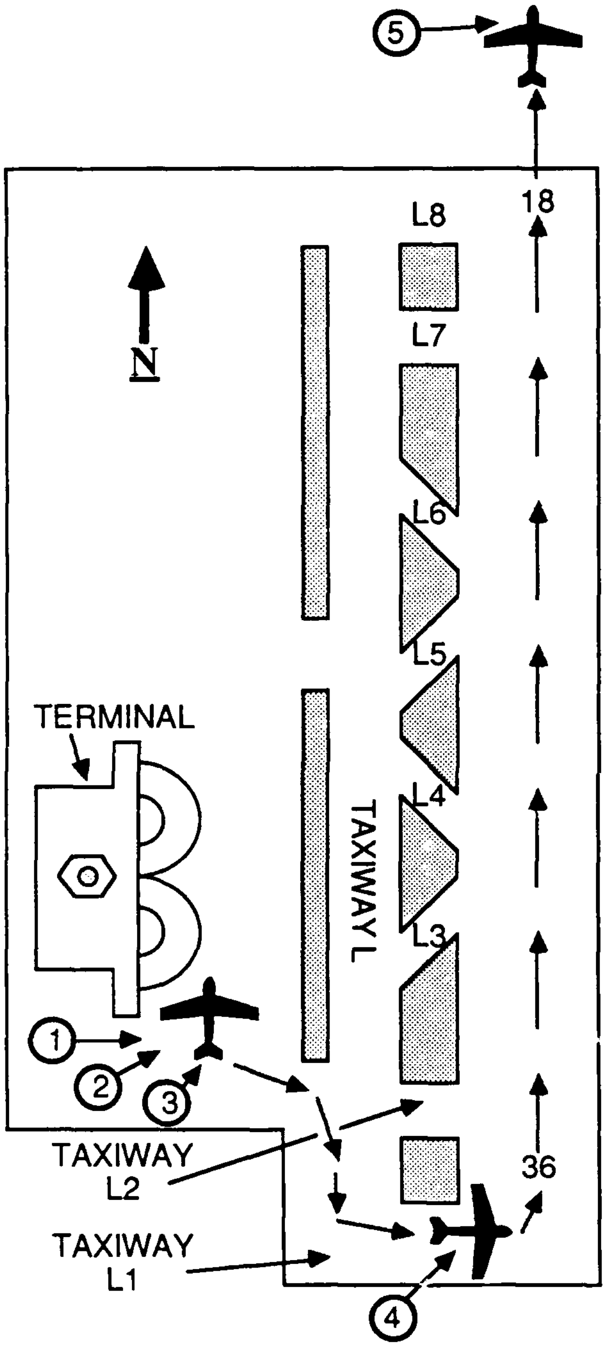
- *Local Controller* duties include departure and arrival spacing, sequencing, and separation of aircraft. This includes clearances and instruction to all aircraft in the Airport Traffic Area and all aircraft/vehicles operating on the active runways. Coordination may be required between multiple Local and Ground Control positions.

The following provides a brief description of the interaction between tower positions. An example of the successive transfers of control on a normal departure is shown in Figure 2.1-27. When ready to depart, the pilot will normally contact the Clearance Delivery/Flight Data position. If the aircraft is on an IFR flight plan, the controller will issue a clearance in accordance with the ATCT/ARTCC letter of agreement or will call the ARTCC for a clearance. A gate hold may be issued if required for traffic management purposes. The controller may need to enter a flight plan or flight plan amendment or beacon code request. The ATIS message will be issued if the pilot does not have the current ATIS. The pilot will be instructed on contacting or monitoring the Ground Controller.

The pilot may request pushback/powerback authorization from the Ground Controller, depending on the gate/ramp proximity to other gate/ramp areas or taxiways The Ground Controller will direct the pilot to a specific taxiway and will specify traffic to follow, if appropriate. If a ground delay is required, the directions will be to a specific area on the airport, if not held at the gate/ramp. The Ground Controller may enter a short flight plan amendment or transfer the flight data back to the Clearance Delivery/Flight Data position for longer amendments, if appropriate. The Ground Controller may need to coordinate with other Ground and Local Controllers on the taxiways to be used and if any active runways must be crossed. The controller may use the BRITE display to determine the current arrival situation. The ASDE display may be referenced for information on ground traffic. The controller will instruct the pilot to contact the Local Controller when the aircraft is in proper sequence and position.

The Local Controller will issue a takeoff clearance taking into account the runways in use, traffic management restrictions, separation between other departure and arrival aircraft, and any other aircraft in the Airport Traffic Area. After takeoff, the Local Controller will direct the pilot to contact the departure controller in the TRACON or TRACAB.

Successive transfers of control on a normal arrival are shown in Figure 2.1-28. VFR arrival aircraft contact the Local Controller for instructions when the pilot is ready to enter the traffic pattern. The pilot will normally inform the controller of the latest ATIS code and the type of option being requested, e.g., touch and go, full stop, etc. The Local Controller will determine where the aircraft will fit into the pattern and provide for the proper sequence and landing clearance.



1 DL478
"DENVER CLEARANCE, DELTA 478 AT GATE C FOURTEEN WITH INFORMATION BRAVO TO LOS ANGELES."

CD/FD TO DL478
"DELTA 478 CLEARED TO LOS ANGELES AS FILED, DENVER SEVEN DEPARTURE, EXPECT FLIGHT LEVEL 370 10 MINUTES AFTER DEPARTURE. DEPARTURE FREQUENCY WILL BE 123.85, SQUAWK 3174, ADVISE READY TO TAXI."

2 DL478
"DENVER CLEARANCE, DELTA 478 READY FOR TAXI."

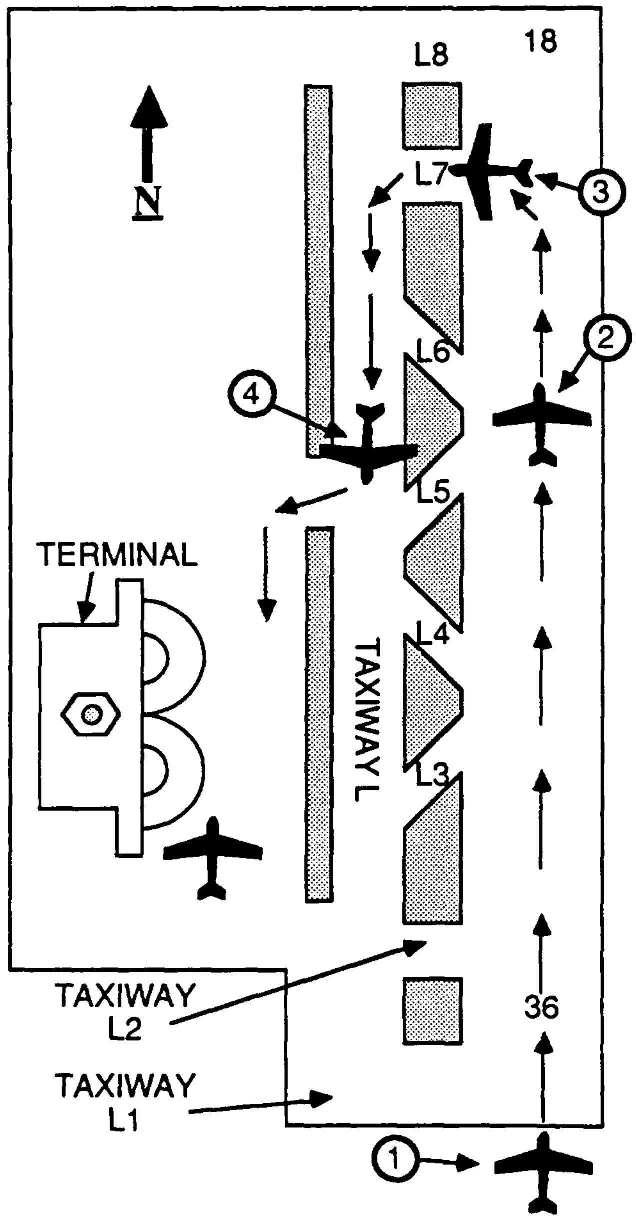
CD/FD
"DELTA 478, MONITOR GROUND ON 121.9."

3 GC
"DELTA 478, RUNWAY 36 VIA LIMA, FOLLOW UNITED 767 TO YOUR RIGHT. MONITOR TOWER ON 118.3 AT LIMA 1."

4 LC
"DELTA 478, CLEARED FOR TAKEOFF RUNWAY 36, WIND 090 AT 10."

5 LC
"DELTA 478, CONTACT DEPARTURE CONTROL."

Figure 2.1-27. Successive Transfer of Control During Normal Departure



(1) UNITED 210 TO LC
"DENVER TOWER, UNITED 210 OVER THE OUTER FOR 36."

LC TO UA210
"UNITED 210, DENVER TOWER, CLEARED TO LAND RUNWAY 36, WIND 090 AT 10, CAUTION WAKE TURBULENCE FROM THE AMERICAN 767."

(2) LC
"UNITED 210, TURN LEFT AT LIMA 7, CONTACT GROUND ON POINT NINER."

(3) UA210
"DENVER GROUND, UA210 ON LIMA 7 FOR GATE BRAVO 6."

GC
"UNITED 210, TAXI VIA LIMA. HOLD SHORT OF LIMA 5 FOR A CESSNA CROSSING RIGHT TO LEFT."

(4) GC
"UNITED 210, TAXI TO YOUR GATE."

Figure 2.1-28. Successive Transfer of Control During Normal Arrival

On arrival of IFR aircraft, the sequence is established by the final controller (in the TRACON/TRACAB) and communicated to the Local Controller. The Local Controller may use the BRITE display or the ASDE for information relating to the position of other aircraft at or near the airport. The Local Controller will issue a landing clearance and ensure that the pilot has the latest ATIS. After the aircraft has landed, the controller will instruct the pilot where to exit from the active runway and to contact the Ground Controller.

The Ground Controller issues taxi instructions to the ramp/gate area, coordinating with other positions as required in crossing other active runways or taxiways. ASDE may be used for tracking through the movement area. When clear of the airport movement area, the pilot leaves the controller's frequency and contacts the ramp/gate personnel, if appropriate. Figure 2.1-29 shows the controllers at their positions in the Tower. Note that two positions here are combined.

2.1.3 Terminal Radar Approach Control (TRACON)

A TRACON may be located in the same building as the Tower or may be in a separate facility. The TRACON may be a collocated facility where controllers rotate through all positions or the facility may have areas of specialization. A TRACAB is always located with a Tower.

2.1.3.1 TRACON Development

Airport surveillance radar was introduced in the 1950s. By the early 1960s, the agency began efforts to apply automation techniques to its flight data and radar systems. At Atlanta Tower the agency established that computers could be used to improve safety and increase the productivity of controllers by using the UNIVAC Automated Radar Terminal System (ARTS). About 145 terminal facilities have now been equipped with ARTS II, IIA, or IIIA. A depiction of the ARTS data path is shown in Figure 2.1-30.

2.1.3.2 TRACON Functions

The basic function of the TRACON is to provide departure and approach control services. Stage II and Stage III procedures have been established at airports with radar approach control. Stage II provides radar sequencing by adjusting the flow of arriving VFR and IFR aircraft into the airport traffic pattern. It also provides radar traffic information to departing VFR aircraft. Standard radar separation is provided for IFR, but not between VFR aircraft or between VFR and IFR aircraft.

Stage III service provides separation and sequencing between all participating VFR and all IFR aircraft. Pilots operating under VFR under Stage III must maintain an assigned altitude/heading. The purpose is to provide separation between aircraft within the airspace defined as Terminal Radar Service Area (TRSA).

TRACON controllers will also provide special VFR clearances within the control zone. An ATC clearance must be obtained before operating within a control zone when the weather is less clear than is required for VFR. A VFR pilot may request and be given a clearance to enter, leave, or operate within most control zones under special VFR conditions, traffic permitting, and provided such flight will not delay IFR operations.

LOCAL (S) | CD/FD | GROUND | UNMANNED LOCAL (N)

Figure 2.1-29. ATCT Controllers

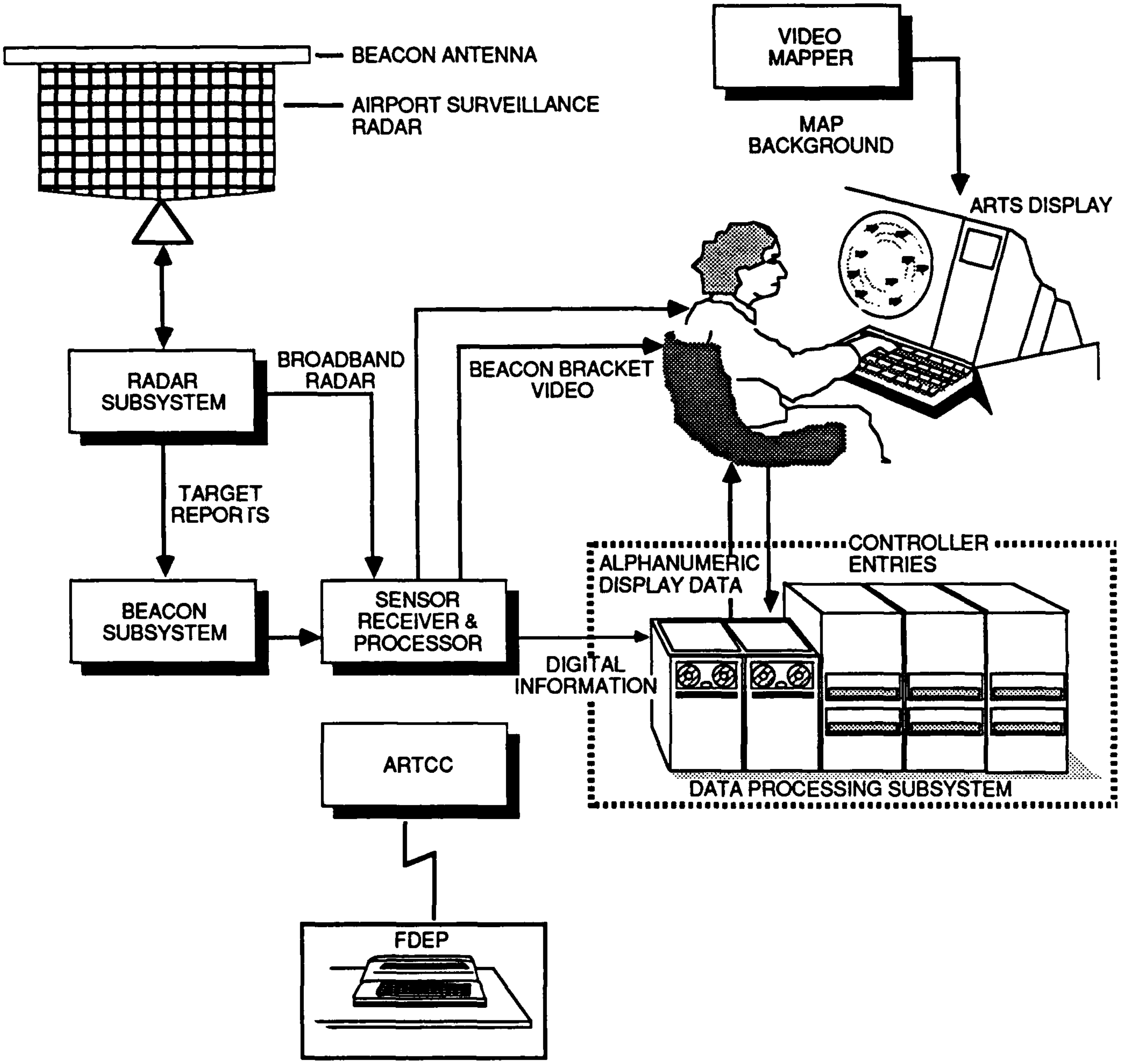


Figure 2.1-30. ARTS Display Data Path

Controllers will issue traffic advisories on other traffic, weather phenomena, and other phenomena such as gliders, balloons, and parachutists. TRACONs equipped with ARTS have special programs to provide Conflict Alert detection between aircraft and Minimum Safe Altitude Warning (MSAW) for terrain avoidance. Upon receipt of a valid MSAW, a safety alert will normally be issued to a pilot.

TRACON Airspace

A Terminal Control Area (TCA) is controlled airspace within which all aircraft are subject to operating rules, and pilot and equipment requirements are specified. Airspace surrounding designated airports wherein ATC provides radar vectoring, sequencing, and separation for all IFR and participating VFR aircraft is known as a Terminal Radar Service Area (TRSA). The service provided is known as Stage III.

Excluding Terminal Control Areas, all airports with an operational control Tower within a TRSA served by a TRACON qualify for the establishment of an Airport Radar Service Area (ARSA). Aircraft operating within the airspace designated as an ARSA are subject to operating rules and equipment requirements. ARSAs will eventually replace TRSAs.

Certain airports may have special published terminal routes. Standard Instrument Departure (SID) and Standard Terminal Arrival (STAR) routes are coded departure/arrival procedures which are established at airports to simplify clearances. These routes are important tools at major airports for flights transitioning from/to the terminal/en route environment. See Figure 2.1-31 for an example of a SID and Figure 2.1-32 for an example of a STAR. There may be special local routes designed for local traffic such as helicopter operations.

Airspace for the TRACON is delegated in a letter of agreement between the TRACON and the ARTCC. The airspace involved is usually less than 50 miles and includes the primary airport and any satellite airports within that radius. The height of the TRACON area is variable and is dependent on the elevation of the airport and the traffic volume/complexity of the control area. A nominal ceiling would be 10,000 feet above ground level.

2.1.3.3 TRACON Equipment

Surveillance of the terminal airspace is provided by two types of radar: primary radar and the radar beacon system, sometimes known as secondary radar. They are located at the same site. Primary radar relies on signals reflected from aircraft and weather. The beacon system receives signals transmitted from airborne electronic equipment called transponders. On aircraft equipped with altitude encoders, the transponder automatically transmits the aircraft's altitude. The beacon system is the main source of surveillance information used for ATC. Primary radar supplements the beacon system and gives weather information. The Airport Surveillance Radar (ASR) provides coverage to a maximum radius of 60 miles. Figure 2.1-33 depicts an ASR.

The Automated Radar Terminal System (ARTS) data entry and display equipment consist of a radar console and associated controls, an alphanumeric keyboard, either a slew ball or peripheral entry module (joy stick), and quick-look buttons or switches. The display is a radar display with alphanumeric data written on top of radar targets. By using the appropriate switches, the controller can display radar targets, weather, video mapping, and digitized data blocks. Communication with the ARTS is through the use of the function keys, slew ball or joy stick, and keyboard.

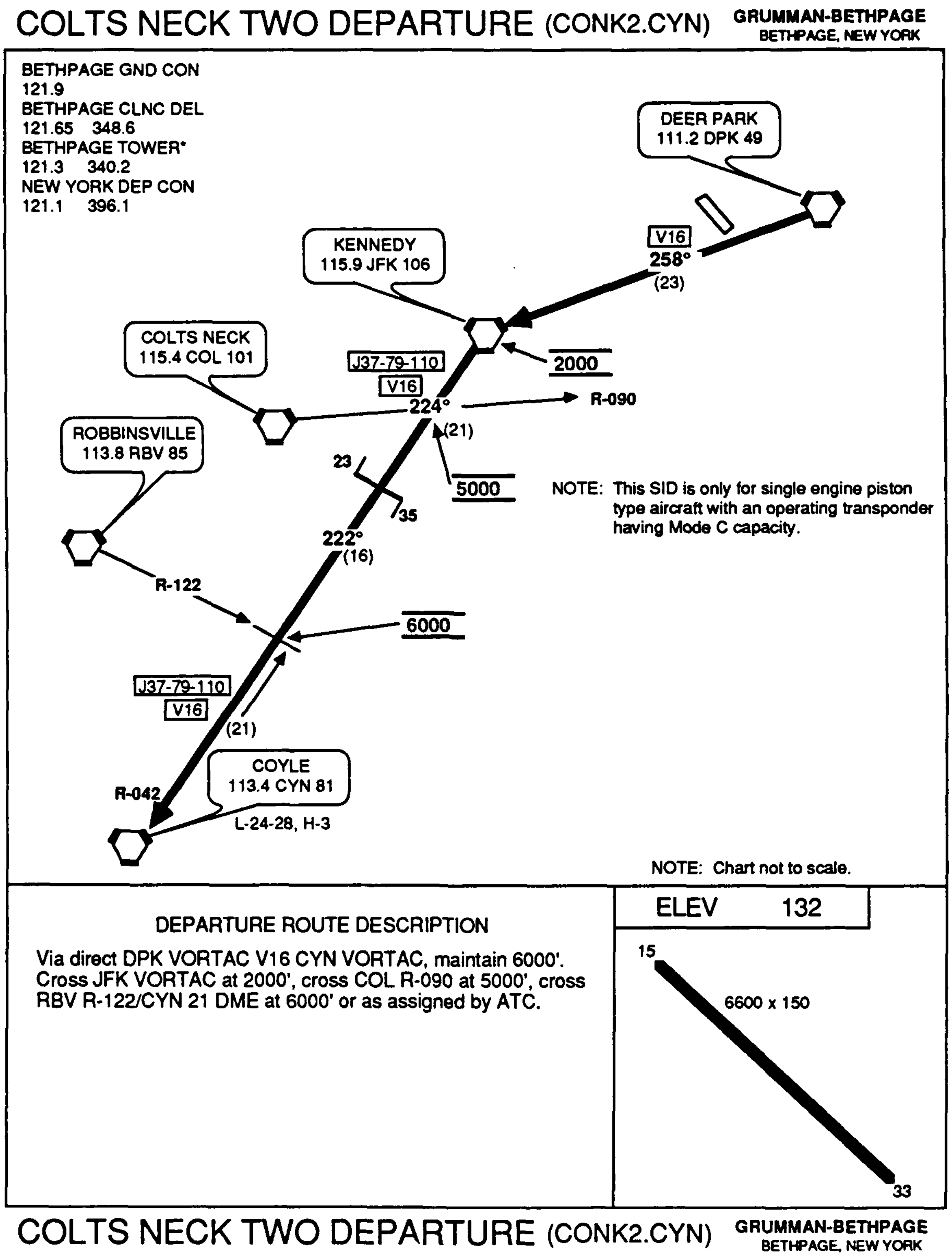
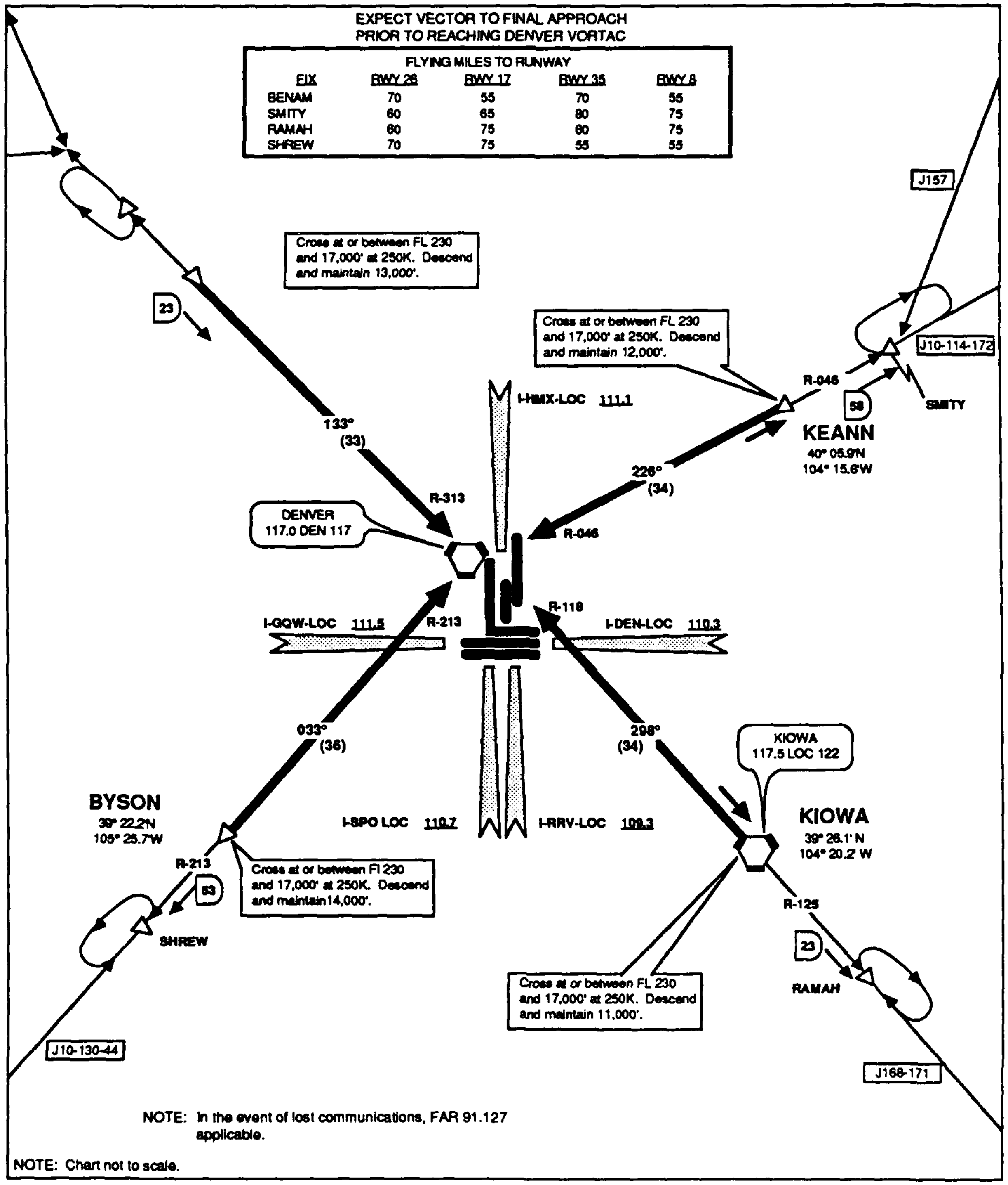


Figure 2.1-31. Standard Instrument Departure (SID)

PROFILE DESCENT RUNWAYS 8-17-26-35

STAPLETON INTL
DENVER, COLORADO



PROFILE DESCENT RUNWAYS 8-17-26-35

STAPLETON INTL
DENVER, COLORADO

Figure 2.1-32. Standard Terminal Arrival (STAR)

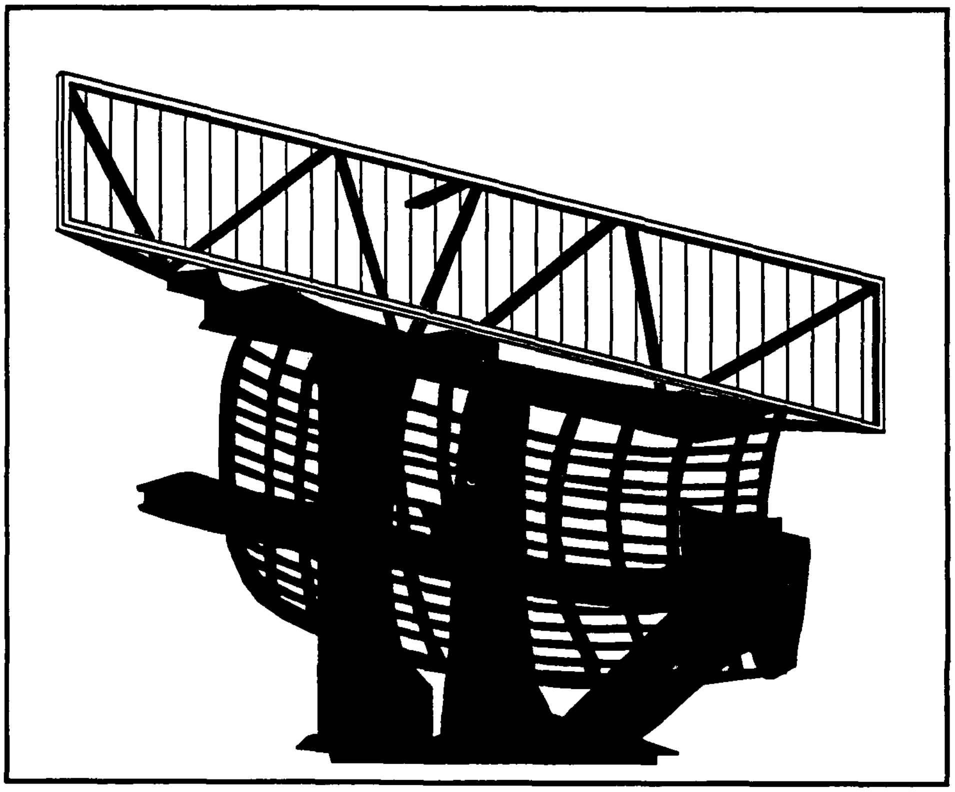


Figure 2.1-33. Airport Surveillance Radar (ASR)

The use of the airborne transponder provides a significant improvement to the original primary radar. It has become the key ingredient in providing automatic identification, track initiation, and altitude reporting data to the controller. The display of Mode C altitude (Mode C is the name of the assigned pulse spacing of radio signals transmitted by an airborne transponder for altitude reporting) is an indispensable tool for the controller and has reduced the pilot/controller communication by a considerable amount. It has also been significant in providing for two safety features: Conflict Alert and Minimum Safe Altitude Warning programs.

Conflict Alert (CA) is a capability within the ARTS to signal the controller that two aircraft are or will come within minimum specified distance or altitude of one another. Minimum Safe Altitude Warning (MSAW) adapts the highest terrain or obstacle for each two mile square bin. It also provides for special adaptation of airport areas to reduce false alerts involving aircraft on approach to a runway. See Figure 2.1-34 for a depiction of MSAW. The CA/MSAW functions are based on actual aircraft positions and movements derived from radar.

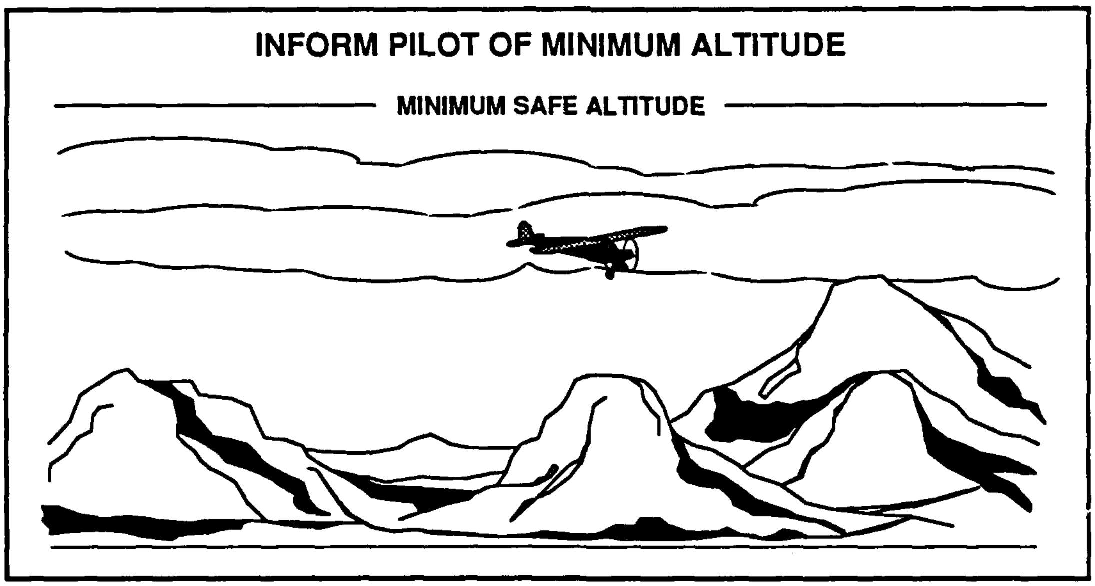


Figure 2.1-34. Minimum Safe Altitude Warning

Flight data in the form of flight progress strips are printed on Flight Data Entry and Printout (FDEP) printers. The strips are produced by the en route Host computer in the ARTCC. Flight plans and flight plan amendments may be entered on an associated keyboard. There is usually one FDEP keyboard and one printer, plus a connected spare printer, in each TRACON. Flight strips of interest to each controller are maintained in flight progress bays, or on a hard rubber mat at the position, where they can be easily accessed and organized as the controller prefers. This system is being replaced by the electronic Flight Data Input/Output (FDIO) subsystem.

All TRACONs are equipped with radio and telephone communications. Radio communications are air-to-ground VHF and UHF transmitters and receivers. Ground-to-ground telephone communications connect the TRACON with the ARTCC, Flight Service Station, ATCT, and other airport offices.

2.1.3.4 TRACON Positions

Facility air traffic managers may use position designators to describe operational positions, such as feeder west, final east, satellite, and handoff. The prescribed positions are as follows:

- *Approach Control* is responsible for providing separation to arrival aircraft in the terminal area using air-to-ground radio and flight progress strips.
- *Arrival Control (Radar)* is responsible for providing separation to arrival aircraft in the terminal area using air-to-ground radio, radar display, and flight progress strips.
- *Arrival Data* is responsible for receiving, distributing, and entering computer messages on arrival flight plans.
- *Departure Control* is responsible for providing separation to departing aircraft in the terminal area using air-to-ground radio and flight progress strips.
- *Departure Control (Radar)* is responsible for providing separation to departing aircraft in the terminal area using air-to-ground radio, radar display, and flight progress strips.
- *Departure Control (Data)* is responsible for receiving, distributing, and entering computer messages on departing flight plans.
- *Coordinator (Radar)* coordinates the movement of traffic between positions. This position also may assist in radar handoffs.
- *Area Supervisor* supervises a team of controllers working specified positions.
- *Area Manager* is responsible for supervision and management of the TRACON.

2.1.4 Other Facilities

Other facilities that directly support the air traffic control function are Flight Service Stations, the Central Flow Control Facility, and military Base Operations.

2.1.4.1 Flight Service Station (FSS)

The Flight Service Station offers a broad range of pre-flight and in-flight services especially aimed at general aviation pilots. These services include:

- Accepting and closing flight plans
- Conducting pre-flight weather briefings
- En route communications with pilots flying under VFR
- Assisting pilots in distress
- Disseminating aviation weather information
- Monitoring radio navigation information
- Originating Notices to Airmen
- Working with search and rescue units.

At certain locations, FSSs take weather observations, issue airport advisories, provide en route flight advisory service, and advise customs and immigration officials of trans-border flights. The stations also relay information to Towers and Air Route Traffic Control Centers.

Major improvements to the FSS are being made which will combine many of the stations and automate many of the functions being performed. Flight movement data will be improved. Computer-aided direction finding will expedite locating lost aircraft. Direct access for pilots will be provided by a computer-generated voice response system. This will permit pilots to retrieve information from an automated weather data base via telephone. Automated weather sensors at selected airports will provide current weather information directly to pilots. Pre-recorded significant weather advisories will be broadcast. Satellite weather photographs will be available at certain locations over facsimile recorders, displaying the location of cloud cover and weather systems.

Eventually the Real Time Weather Processor and the network of Doppler weather radars will be provided to the Automated Flight Service Stations (AFSSs). Mode S data link will improve communication capabilities.

Many of these improvements are under way and will continue into the year 2000. These are recorded into updates of the NAS Plan [20].

2.1.4.2 Central Flow Control Facility (CFCF)

The Central Flow Control Facility has overall responsibility for system-wide traffic flow management. To optimize the system traffic, this facility applies the system delays and/or rerouting of traffic. These actions, normally referred to as flow control or traffic management restrictions, are in response to capacity limitations at selected airports, control sectors, route segments, or navigation fixes. This facility interfaces with Air Route Traffic Control Centers and designated Terminals/Towers for monitoring of traffic situations.

2.1.4.3 Military Base Operations (BASOPS)

The military Base Operations perform for military pilots the same flight plan and weather services as the Flight Service Stations perform for general aviation pilots. If Base Operations are

not available, the military pilot will generally contact a Flight Service Station for weather and flight plan services.

2.2 PLANNED AIR TRAFFIC CONTROL ENHANCEMENTS

It is anticipated that future improvements for the Advanced Automation System (AAS) will have a profound impact on Air Traffic Control. These improvements will include such items as Real Time Weather Processor; Mode S data link; Advanced Traffic Management Systems; Voice Switching and Control System (VSCS); Tower Communications System (TCS); terminal and en route radar systems, such as Doppler weather radar and ASR-9; advanced stages of automation processing, such as AERA II; and navigation by Global Positioning System (GPS) satellites.

2.2.1 Improvements Preceding Full ACCC

Prior to the implementation of the full Area Control Computer Complex (ACCC), the en route control will be accomplished through the Initial Sector Suite System (ISSS) and the terminal control will be accomplished through the Terminal Advanced Automation System (TAAS) and the Tower Control Computer Complex (TCCC).

Basically, the ISSS will allow early use of the Sector Suite workstation and associated man-machine interface capabilities. The Sector Suites will not be processing data as envisioned in the ACCC except for the display of control information. Data processing will occur in the Host Computer System currently being installed in 20 ARTCCs, with Enhanced Direct Access Radar Channel (E-DARC) used as a backup. The Host is an IBM 3083 computer which has replaced the original IBM 9020 computers as an interim upgrade needed to handle traffic until the ACCCs become available. The Host program will increase computer capacity four times, and increase computer speed seven to eight times over the IBM 9020.

The aging ARTS equipment will also be replaced by the Sector Suite equipment. In this case the ARTS ATC functionality will be accomplished by Sector Suite processing both for the display of radar and flight data and most of the respective lists associated with the ACCC. In this manner a subset of the computer programs identified for use in the ACCC will be checked out by the TAAS minus some of the more complex routines involving extensive flight plan processing, flight plan extrapolation, flight plan conformance checking, conflict resolution advisories, and automation processing (AERA) capabilities.

To provide the full ACCC, it will be necessary to upgrade and combine the TAAS and the ISSS, along with additional automation features such as AERA 1 capabilities. At that time the controllers will have had extensive experience with the Sector Suite equipment and the man-machine interface, facilitating transition to ACCC. This should also help the Area Control Facility transition wherein en route and terminal operations are combined into one facility. Thus, arrival at the full ACCC system will be accomplished through an evolution of several transition states from the present NAS Host to ISSS, TAAS, ACCC, and AERA 1.

2.2.2 Area Control Facility (ACF)

The National Airspace System (NAS) Plan [20] outlines the objective of the full Advanced Automation System (AAS) as the consolidation of the operations of multiple terminal radar approach control facilities (that are located in the same geographic area) into Area Control Facilities

(ACFs). The collocated facilities will be responsible for arrival, departure, and en route control of air traffic. A distinction will not be made between en route and terminal operations, as the integration of these functions is one of the FAA goals that the AAS supports. A distinction is made according to sector types to assure that the unique characteristics of terminal approach control operation are understood and preserved. The concept of ACF operations, including an overview of how the individual controller will be employed in carrying out these Air Traffic Control operations, is summarized in this section.

The consolidation of en route and terminal controller facilities into ACFs is intended to achieve the following mission-level ATC goals:

- Integration of functional responsibility for the safe, orderly, expeditious flow of air traffic
- Ensurance of uniformity of concept application throughout the ATC system
- Increased automation of air traffic separation services and flight data processing
- Unrestricted operational data interchange
- Integration of sectors to include control of en route and terminal airspace
- Increased productivity of controllers through enhanced automation
- Reduced overhead staffing
- Reduced boundaries between approach control and en route functions
- Reduced need for interfacility transfer of control of aircraft
- Increased automation to transfer more of controller workload to the machine.

To paraphrase, the overall goal is to improve Air Traffic Control service to users, increase Air Traffic and Airway Facilities personnel effectiveness and productivity, and absorb traffic growth through consolidation of ATC facilities, while maximizing the utility of advanced automation.

ACFs will have realigned boundaries based primarily on traffic flows throughout large geographic areas, accommodating arrival, departure, and en route control in one type of facility. All necessary control Towers will remain in existence, but radar approach control will be consolidated within the ACF.

Figure 2.2-1 depicts the top-level operational elements of the NAS ATC system. The major components of the system are the ACFs, the Airport Traffic Control Towers (ATCTs), and other external facilities such as military Base Operations (BASOPS). Figure 2.2-1 shows flow of information between/among ACFs, to and from aircraft, as well as the necessary coordination between ACFs, ATCTs, and other facilities. This shows at a very high level the different types of interfaces with which the ACF controller is involved, and establishes a basis for a more detailed look at the composition of controller tasks and dialogue descriptions in later volumes of this series of reports.

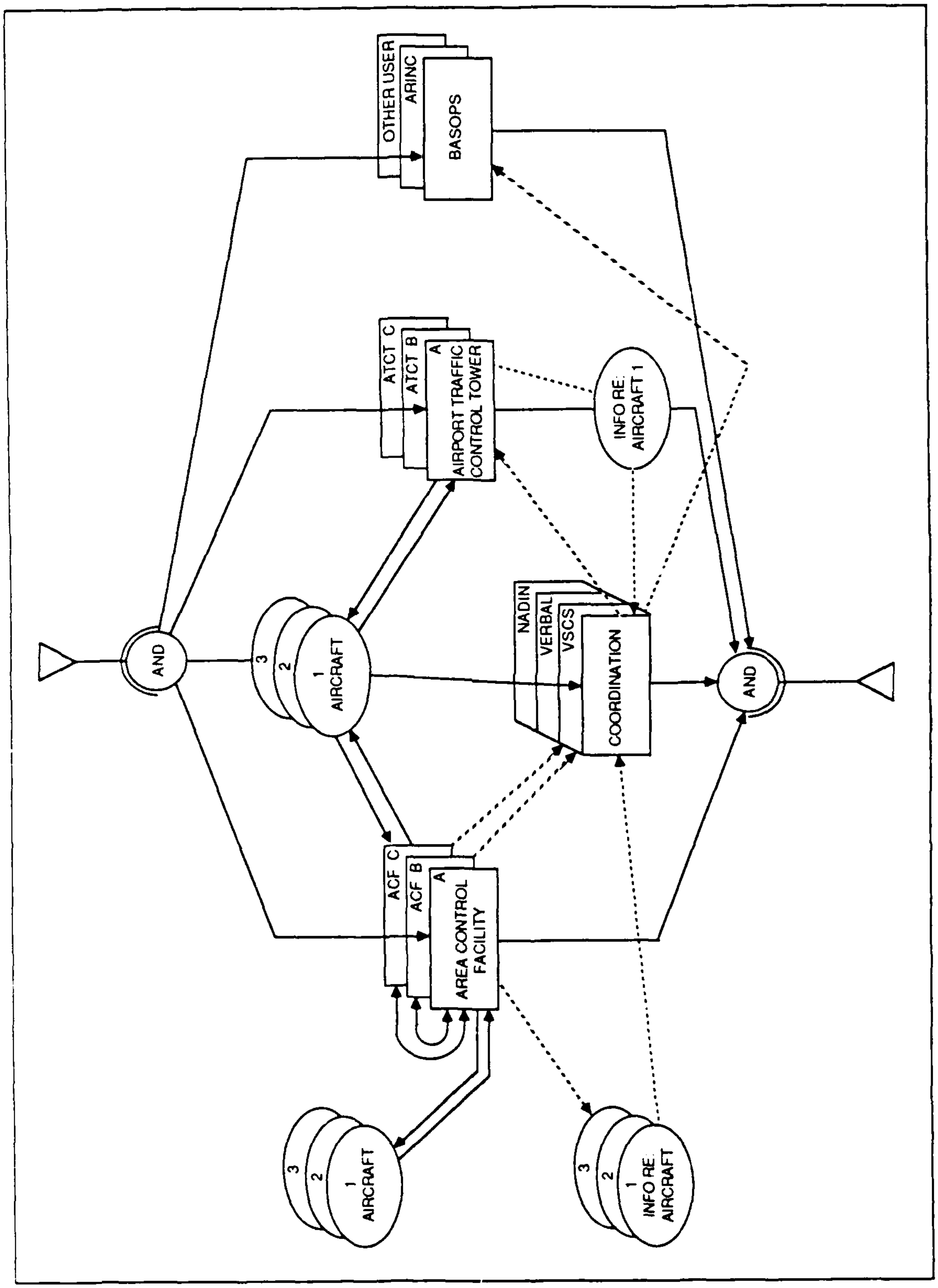


Figure 2.2-1. ACF Operational Concept

The solid-arrowed lines in the graph show how the planning and control responsibility for a specific aircraft moves through the system. The dashed-arrowed lines indicate the flow of information through the system. For example, information may be passed from an ACF to the pilot of an aircraft. This information, as well as information from other ACFs, may be passed along to an appropriate ATCT or other facility after having been coordinated with other incoming information. The coordination of information may be done either by the National Data Interchange Network (NADIN) or via the Voice Switching and Control System (VSCS). The concurrency notation (AND) superimposed on this graph shows that each of the indicated functional elements operate in parallel with others.

Figure 2.2-2 depicts ACF interfaces in composition graph form similar to Figure 2.2-1. This graph depicts a number of sectors within an ACF and shows the relation between the flow of information and control external to an ACF. Inputs that are external to the ACF, such as traffic management advisories, flight plans, flight plan amendments, surveillance data, weather data, aircraft communications, and status information, are transformed by ACF operations and automation functions into clearances, advisories, safety alerts, coordination information, transfer-of-control data, and system status information. These outputs are distributed to entities outside the ACF, such as aircraft, other ACFs, or ATCTs.

Figure 2.2-2 illustrates the coordination of weather information (WX) and information from a pilot and the flow of that information to the appropriate Sector Suite (controller workstation). This information then is transformed into handoff data (in this example) and passed along to another pilot. The information is coordinated verbally, by NADIN or VSCS, and also through the Sector Suite (S/S) interfaces (ATC Mail or Aeronautical and Meteorological Data Display). Finally, in this example the information is coordinated with controllers in an ATCT.

2.2.2.1 Facility-Level Description

According to the NAS Plan [20], en route and terminal facilities will be consolidated into ACFs. This consolidation features the use of common computers and Sector Suites. A Sector Suite is a group of one to four Common Consoles forming a workstation containing displays and input devices whereby ATC specialists interface with the computer automation systems, first within ISSS and TAAS facilities and eventually with the Area Control Computer Complex (ACCC) in ACFs. Within each ACF, computer processing will be divided between common processing equipment and the individual Sector Suites. Multiple Sector Suite displays will provide a plan view of the air traffic and weather situation, alphanumeric flight and weather data, and other aeronautical information such as Notices to Airmen (NOTAMs), and traffic planning data including the ability to probe the system for conflict-free flight paths. Sector processing and the failsoft and emergency modes will ensure that required surveillance, flight data, and weather information are available at the particular controller position.

The purpose of the AAS is to provide a total automation system that includes the ACF controller Sector Suite, new computer software, and new processors to augment the host computers in the Initial Sector Suite System (ISSS). The AAS will provide: (a) the capacity to handle the projected traffic load through the year 2000 with increased productivity through introduction of new Sector Suites at the earliest practical time; (b) a high degree of reliability and availability; and (c) the capability for enhancement to perform other functions subsequently introduced into the system. Software functions that are now unique to the terminal ATC systems

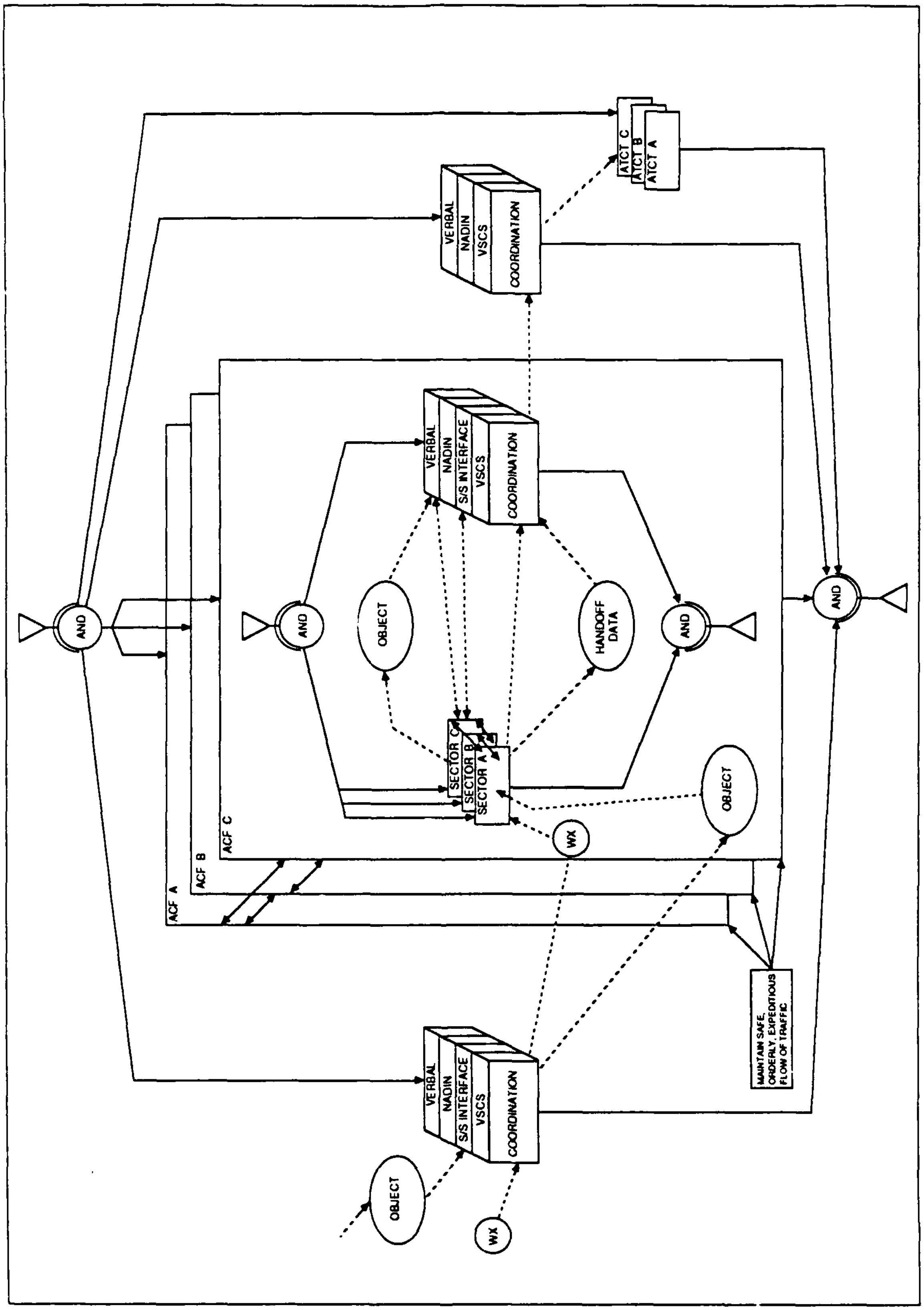


Figure 2.2-2. ACF Interfaces

will be incorporated into the new software to support Area Control Facilities. All remaining elements of the current en route automation hardware and software will be replaced.

The full AAS will make possible the integration of en route and terminal operations in the ACFs. The tower cab Tower Position Consoles will be installed when terminal radar control is operationally integrated into the ACFs.

Distributed processing will inherently provide high availability and protection from total system failure. Increased operational flexibility can be achieved, since the number of controller operating positions can be reconfigured to meet changing demand based on day-to-day or hour-to-hour workload requirements. When traffic decreases, Sector Suites and associated VSCS communications can be configured into larger operating sectors, and the total number of operating positions and associated staffing can be reduced.

The advanced functions of the Automated En Route Air Traffic Control (AERA 2 and AERA 3) program will be added to the AAS in incremental steps. Direct fuel-efficient route planning and traffic management will be added before strategic planning and full tactical clearance generation. During the latter phases of the NAS Plan, weather and flight information and eventually computer-generated clearance messages will be transmitted directly to aircraft pilots via data link.

2.2.2.2 ACF System Elements

Although the main activities in an ACF are centered around the Area Control Computer Complex (ACCC), there are other equipment and activities that also will be part of an ACF. Each ACF also will include communications equipment, as well as space and equipment for administrative and training activities. Each ACF will include a NADIN concentrator, a Real Time Weather Processor (RWP), and a Flight Service Data Processing System. The system elements of most concern with respect to the Operations Concept are the following:

1. Area Control Computer Complex (ACCC)

The ACCC is the equipment and software that provide automation support for the control of aircraft in a volume of airspace under the air traffic jurisdiction of an ACF. The equipment and software of all ACCCs will be identical, varying only in installation quantities and in software adaptation to the operational configuration of the ACF sites.

An ACCC includes computers, computer programs and related documentation, displays, storage devices, output interconnecting communications, a supporting maintenance subsystem, a training subsystem, and interfaces with other FAA systems and facilities. An ACCC does not include communications that are external to the building that houses the ACF, voice communications, or any equipment at surveillance sensor sites.

2. Sector Suite (S/S)

The Sector Suite is the workstation consisting of one or more Common Consoles containing displays and input devices whereby ATC specialists (ACF controllers, coordinators, supervisors, and managers) interface with the ACCC. Sector Suite refers to the composition of functions that directly comprise either the ACF controller man-machine interface (MMI) or the Sector Suite Console/Support processing elements. For the man-machine interface, the Sector Suite is the

collection of data entry and display equipment that is required at an operational position during the Initial Sector Suite System (ISSS) or full Advanced Automation System (AAS) time frames.

3. Maintenance Processor Subsystem (MPS)

Within each ACF is a collocated Maintenance Processor Subsystem. Each MPS , as part of the FAA's Remote Maintenance Monitoring System (RMMS) will be positioned in a central location for equipment performance monitoring, certification, and control of remotely located FAA facilities in a given geographic area. The ACF will send system status, performance, and alarm messages to the MPS on a periodic basis. The MPS will send messages to the ACF requesting that system data be transmitted to the MPS. The MPSs will be interconnected to the ACCC and to each other in other AFCs in a nationwide network via the National Data Interchange Network (NADIN).

4. Real Time Weather Processor (RWP)

Each AAS will be linked by local communications to obtain digital weather data and weather products and to provide PIREPs collected by ACF controllers. Three types of messages flow from the AAS to the RWP: (a) requests for products and services; (b) PIREPs collected by the sector; and (c) temporary adaptation list changes. In addition to data disseminated automatically, the AAS may send request and reply messages to the RWP for any data not normally stored by the AAS. Temporary additions to the standard list of required weather data may be requested by the AAS.

5. Voice Switching and Control System (VSCS)

The ACF Sector Suites include the integrated use of the Voice Switching and Control System. The VSCS is the primary means for establishing ACF communications in the NAS Air Traffic Control system. These communications consist of ground-to-ground (G/G) links among ATC personnel in the same facility (intercom) and in different facilities (interphone), and air-to-ground (A/G) links between air traffic controllers and pilots (radio). The VSCS can select, connect, and automatically reconfigure ground-to-ground and air-to-ground circuits as needed to meet operational, maintenance, and support communication requirements. The VSCS G/G and A/G display panels will be integrated with and housed in the Common Consoles of each Sector Suite.

Data exchanged between the AAS and the VSCS will permit control of the voice communications system configuration in response to changes in the ACF configuration. These changes will be made as a result of AAS inputs by supervisory personnel. The AAS will provide to the VSCS the data on the configurations themselves, commands to establish a given configuration, and inquiries about configurations and current system status. The VSCS will provide appropriate status and response information to the ACF.

6. National Data Interchange Network (NADIN)

NADIN will be a national data communication network that will serve the various ACF computer complexes and equipment. NADIN will have sophisticated message routing and interface capabilities to enable transmission over one of several paths and interoperability with a number of different networks. NADIN will control and route messages on the network through two or more national switches. NADIN concentrators to be collocated at selected ACFs will interface to all ACFs and provide access and interface to the network. The NADIN concentrator will perform the total data communications function. It will add the appropriate communication

information, format messages received from the ACF, and control the transmission of the messages to the destination facility/equipment.

2.2.2.3 Operational Descriptions

This section describes air traffic operations after the full AAS becomes operational at field sites. This section should be considered as guidance to understanding changes from current Host Computer System to future AAS operations.

ACF Sectorization

ACFs will be formed by combining into a single facility the air traffic control of airspace accomplished by several TRACON/TRACAB facilities and the adjoining en route sectors. This will result in reduced coordination between separate facilities and in re-aligned sectors which can better accommodate inbound and outbound traffic flows.

In general, there are seven types of sectors: low altitude arrival, low altitude departure, low altitude en route, high altitude en route, oceanic, arrival control, and departure control. These types of sectors, in certain instances, will be structured to serve more than one purpose. For example, they may in certain traffic conditions be reconfigured (combined or decombined). Equipment outages (e.g., Common Console preventive maintenance) may result in reconfiguring sectors.

A sector of airspace may be controlled by one to three controllers operating at a Sector Suite workstation. Workstations and controller teams will be configured as a function of sector type, traffic volume, traffic sequences, and interfacility interfaces. Workstations will contain from one to four interlocking Common Consoles consisting of interaction devices, displays, and the VSCS panel(s).

The number of sectors per ACF will range from 60 to 120, depending on the size and type of facility. During peak traffic periods, sectors may be "decombined" into smaller geographic areas or a lower level of air traffic control specialization (e.g., splitting the arrival control sector to accommodate dual approaches). Slow periods of traffic may require the "combining" of sectors, especially during early morning or late evening shift periods. An example of combined sectors may occur when departure sequences are handled by the low altitude controller, thus consolidating the departure control and low altitude sectors.

This strategy of combining sectors may be feasible given improvements in sensor technology and in procedures for handling traffic sequences. Consolidation will bring about a re-thinking of ACF sector configurations to regulate controller workload, and yet improve handling of traffic sequences at primary and secondary (satellite) airports, and provide more fuel efficient flight services.

Controller Coordination Philosophy

Currently, verbal controller coordination between sectors (between facilities or within the same facility) and with pilots is a significant workload demand. The ACCC (within the ACF) will facilitate coordination by providing machine functions that will allow:

- Automatic handoff of control between sectors
- Automatic pointouts
- Automatic distribution of weather data such as PIREPs, SIGMETs, and forecasts
- Automatic posting of flight information for aircraft about to enter sector airspace.

In all cases the controller may override automatic options; i.e., ultimate responsibility for aircraft separation and control will still lie with the controller, not the computer.

The system will provide the controller with the ability to compose and enter messages for automatic routing and display at other controller or supervisory workstations, both intrafacility and interfacility. VSCS will facilitate coordination, with capabilities for conference calling and direct access to internal and remote facilities. It also will permit call forwarding and queuing of incoming calls, as well as transmission of priority calls.

A controller does considerable coordination with other controllers to assure smooth and efficient handling of traffic, to coordinate delays caused by facility restrictions and weather, or to resequence inbound/outbound traffic due to runway changes. This type of coordination should be addressed by the ACCC design.

ACF Sector-Area Team Organization Philosophy

The Area Supervisor is the resource manager for a group of Sector Suite Teams. The supervisor will be able to determine sector workload through sector workload probes, and cause sectors to be reconfigured (combined or decombined) in response to traffic situations. This becomes an effective way to balance workload and maintain controller alertness levels.

At the Sector Suite level, the ACCC provides the controller(s) with machine aids for carrying out supervisory directives to reconfigure the controller workstation and respond to anomalous situations, such as equipment failure or loss of a functional capability.

Controller Training and Certification

Each controller will be required to gain training and proficiency in several areas, i.e.,

1. Workstation familiarization and MMI language proficiency
2. Facility Military Operations Areas (MOAs), procedures, etc.
3. Radar Controller, Data Controller, Handoff Controller, or Terminal Coordinator position proficiency
4. Specific sector position certification.

Through the course of their career at an ACF, controllers will obtain certifications or checkouts in various positions and types of sectors. A Full Performance Level controller is an individual proficient in mastering the concepts and tasks at all positions in an area of specialization.

The ACCC will incorporate a training system composed of computer hardware and software, problem test cases and operational scenario simulations, and a training director to enable the trainee to gain proficiency in factors 2, 3 and 4 above. This hands-on "classroom" training will be supplemented by on-the-job training at the controller workstation. Separately, for more academic instruction, there will be an Advanced Automation Training System, which will present computer-based instruction via student learning terminals.

Real-Time ATC Operations

The controller is characterized as an event-sensitive information processor in Section 3.1. The air traffic controller has been trained to mentally anticipate any potential control problems and yet provide for expeditious traffic flow. The controller is and will continue to be operationally responsible for the separation of air traffic. During real-time operations, track information will be presented on the Situation Display. The controller is responsible for visually separating targets and/or mentally preserving the spatial distance between objects. The AAS will provide powerful machine aids, such as improved terminal and en route Conflict Alert and Minimum Safe Altitude Warning (MSAW), a new flight plan conflict probe, improved capabilities for display of special lists and flight information, and display of current and forecasted weather conditions.

The controller team at the Sector Suite workstation will integrate and use this information not only to facilitate the safe and expeditious flow of traffic under their control, but also to coordinate information with other sectors within the ACF and with other sectors or positions at other facilities (e.g., adjacent ACFs, ATCTs). This coordination will be made possible by voice switching communications (VSCS) previously installed in the Initial Sector Suite System (ISSS), automatic intra- and interfacility mail message transfer, automatic function message transfer (e.g., pointout and handoff messages) between workstations, and even direct person-to-person voice communication in some instances.

Sectors affected by low density traffic patterns during off-peak periods may be "combined" to maintain consistent controller workload. Other sectors affected by peak traffic conditions may be adjusted in staffing or become "decombined," resulting in sharing of workload. These "controller resource management" options will be proceduralized and supported by adaptations of sector geography, location of transmitter/receiver sites, sensor coverage, and ATC procedures. Effecting these options will be the responsibility of ACF Area Supervisors.

In later phases of AAS evolution, operations may evolve to higher levels of automation where the capabilities of the Mode S data link are used to transmit advisory weather data and clearance information to the pilot. However, a mix of aircraft capabilities will exist that will continue to require the full range of ATC services. These include:

- Voice communication of clearance and advisories to aircraft not equipped with Mode S data link processors

- Voice and data link communications of advisory and flight-following information to pilots

- Backup voice communication in the event of data link or on-board flight equipment outages.

Eventually the role of the controller in this era of advanced automation may, in some sectors, be more monitoring in nature, with the controller handling exceptional events. However, certain sector types and conditions (such as severe weather or airport restrictions) will require the controller to be an active participant in the control of air traffic. It is important to recognize that in real-time ATC operations, maintaining controller alertness, skill levels, and capabilities will be extremely important to the "availability" of services to pilots. Controllers, like pilots, experience boredom, yet each must be provided with capabilities to respond to operational events such as weather, aircraft anomalies, airport restrictions, changing traffic sequences, etc.

ATC Operations Standardization and Transparency

Standard operating procedures are a necessity in the National Airspace System. These procedures permit the common evaluation of operational performance on an ACF-by-ACF basis and also facilitate the use of consistent ATC practices among controllers.

Many procedures in the Air Traffic Control handbook, Order 7110.65 [18], will be modified to reflect use of new computer technology, more reliable and accurate surveillance/NAVAID capabilities, improvements in the controller workstation, and sectorization changes brought about by consolidation. New and old procedures must be embedded in the Advanced Automation Training System. Special attention needs to be focused on the negative transfer effects of transitioning from old practices to new procedures.

The FAA Air Traffic Service has stipulated that certain existing ATC operations remain transparent to the controller during the initial phases of full AAS deployment. These include:

- Presentation of Situation Display data should remain functionally similar, where Full Data Blocks are adapted in the ACF to terminal and en route types of sectors

- Presentation of geographic data and sector adaptation data

- Presentation of airway/route structure data

- Implicit (automated) or explicit (controller-invoked) initiation of handoff

- Preservation of many current operating procedures and Military Operations Areas.

Different systems (e.g., ARTS II/III, IIIA, and NAS Stage A) have brought about certain practices resulting in use of different target symbology, use of flight information, and mosaic versus non-mosaic processing of sensor data. The ACF and AAS will bring standardization of displayed information and controller workstations. Controller workstations may be adapted to present standard information displays to a team of 2-3 controllers or to a single controller. The AAS also will provide the flexibility to tailor the presentation of flight, advisory, and display information as a function of Sector Team size, sector type, and limited controller preferences. For example, tailoring the Flight Data Display might involve sorting and presenting Flight Data Entries (FDEs) by time of arrival over a fix or by call sign (alphanumeric order).

The system will provide time-sequenced voice and data recording of displayed information and controller input actions. This will make possible the playback of events to enable reconstruction of incidents, as well as evaluation of standard practice.

Operational Availability of ATC Services

One of the main goals of the AAS is extremely reliable and accurate processing. For the AAS, the overall reliability design goal is to provide full service operation within the response times for the ATC services supported by these operations, 24 hours a day, 7 days a week.

In principle, this philosophy provides for a full range of failure coverage for essential ATC functions such that, if one function fails, other essential services (functions) are not degraded; and, if a function does fail, that function is restored using a recovery scheme which informs the controller and/or supervisor. Other essential services continue without degradation. Critical functions such as track processing will be provided sufficient levels of protection and fall-back modes so that even the enabling of a fall-back option does not adversely affect the performance of other ATC services.

Response time, equipment, and software failures will inevitably occur and be visible to the controller or supervisor. Each Sector Suite workstation and associated support processing will be required to recover within a specified response time. Failure to recover within the specified response time will result in unavailable ATC services.

Hardware and software failures may still occur. However, automatic error detection, isolation, and recovery techniques will be provided to preclude full-service interruptions. Specific controller actions (e.g., switchover to backup procedures) will be required in the event of:

- Individual interaction or display device failures
- Sector Suite failures
- Loss and/or degradation of ATC functional capability.

Attention must also, of necessity, be paid to other failures that occur, such as loss of radio aboard aircraft, NAVAID failures, sensor outages, and loss of air-to-ground communications or interfacility communications. The Composition Graphs (Section 3.2) presented in Appendix A of the data volumes include the provision for tasks that respond to these events at a design/architecture-independent level.

2.2.3 ATCT Enhancements

As described in the NAS Plan [20], a Tower Control Computer Complex (TCCC) will be developed, as part of the AAS, to support operational controllers in the tower cabs. Tower controllers will interface with the TCCC via a Tower Position Console (TPC), which will provide functionality and performance appropriate to the Tower environment. The TCCC will use ACF Sector Suite components as far as possible, but will use unique displays (hardware and software) appropriate to the space limitations and ambient light conditions found in Towers. Tower suites will draw on terminal, en route, and FSS data bases to satisfy the traffic control requirements for radar flight position, intent and identity, flight data, weather data, and flow planning information.

The TPC will be configurable to any of four different modes: Local Control, Ground Control, Clearance Delivery/Flight Data, and Supervisory/Maintenance. Like the ACF Sector Suites, the TPC will be capable of adapting to controller preferences. Reconfiguration in response to workload changes is even more critical in the Tower than in the ACF, and will also be provided. The TPC MMI will take into account the Tower controller's need to view the airport and adjacent airspace through the tower cab windows, a requirement whose analogue is not found in the ACF. A Tower Communications System (TCS) will be provided for the Tower controller's use, and will include most of the features of the VSCS.

The TCCC will be able to make use of improved weather data from ASR-9 and/or Terminal Doppler radar. In addition, the TPC MMI will provide for Airport Surface Detection Equipment (ASDE) data to be available at all Local and Ground Control positions.

2.2.4 Advanced Traffic Management System

Traffic management in the current environment is accomplished through interaction of personnel in Towers, Centers, and the Central Flow Control Facility (CFCF). These facilities are described above in Section 2.1. The Advanced Traffic Management System (ATMS) will be developed to balance the air traffic demand with the NAS capacity in a safe and effective manner in the environment of the year 2000 and beyond. ATMS goals are defined as follows:

- Maximize throughput of traffic through the NAS
- Ensure a balanced controller workload
- Improve air transportation safety
- Conserve fuel
- Allow the airspace user the widest possible freedom and autonomy in flight operation
- Improve the human-computer interface.

ATMS will operate using flight data, airspace data, weather data, equipment status data, and general policies and procedures. It will monitor the traffic management situation, predict problems, and develop solutions to traffic management problems (not conflicts of individual aircraft with flow restrictions) in order to utilize system capacity effectively without overloading any airway or facility. Since most ATMS data are received from AAS, and solutions to problems are implemented via AAS, close interaction and complete compatibility between ATMS and AAS will be essential.

ATMS will perform additional functions, including servicing inquiries, performing post-mortem analysis, and operating the Emergency Operations Facility, the Central Altitude Reservation Facility, and the Airport Reservation Office.

An Operations Concept (functional description) for the ATMS is provided in the Advanced Traffic Management System Operational Concept Description [11].

2.2.5 Advanced En Route Automation

The controller's job is described elsewhere in this document as event-sensitive: that is, acting generally in response to events rather than initiating action independently or unilaterally. Thus, in the current environment, the controller typically thinks and acts in a "tactical" mode, where the need to plan for and accommodate developments during the next few minutes occupies nearly all available time. The objective of Automated En Route Air Traffic Control (AERA) is to enhance system safety and efficiency while increasing controller productivity, by enabling the controller to think more in "strategic" terms and less in "tactical" terms. As currently envisioned, AERA processing will operate on flight data, radar data, status data, and guidance provided by the controller. Ultimately, AERA may reduce the controller workload by initiating certain control actions unilaterally, subject to controller review and veto.

Three stages of AERA implementation are proposed, called AERA 1, AERA 2, and AERA 3. AERA 1 is part of the AAS package and will be implemented in the mid-1990s. An Operations Concept for the domestic en route controller in the AERA 1 environment appears as Volume II of this document. AERA 2 is to be the first enhancement to the AAS, followed some time later by more system enhancements in AERA 3.

AERA 1 will introduce the following automated capabilities [12]:

- Detection and notification to the controller of possible conflicts among flight plans and between flight plans and special use airspace (the existing radar-based conflict alert and minimum safe altitude warning functions will be maintained as well)
- Detection and notification to the controller of possible flight plan violation of flow and metering restrictions
- Detection and notification to the controller of problems in candidate (trial) flight plans that the controller is considering implementing
- Detection and notification to the controller of aircraft that are out of conformance with their flight plans, and assistance in identifying maneuvers to reestablish conformance
- Tools to assist the controller in constructing candidate (trial) flight plans
- Messages to remind the controller of control actions to be taken (e.g., "start of descent")
- Estimation of selected current and future sector workload factors to aid the controller in planning and prioritizing tasks.

AERA 2 currently is planned to introduce the following new capabilities:

- Computer-generated resolution of conflict, noncompliance, and nonconformance problems

- Automated coordination (nonvoice communication) in certain specified instances between sector controllers or between a sector controller and a Traffic Management Coordinator

- Static or dynamic display of projected traffic in a format similar to that of the Situation Display.

Further information on AERA 2 planned enhancements may be found in the AERA 2 Operations Concept [12]; specific AERA 2 contents, as well as those of AERA 3, are still evolving.

2.3 ATC DEVELOPMENT SUMMARY

As stated in the National Airspace System Plan [20], today's air traffic control system is a combination of equipment, procedures, and employee skills that have evolved over forty years. This evolution has produced a mixture of equipment of various ages, technologies, and types. It is an extremely safe system but it is very expensive to operate and maintain, expansion is limited, and adaptability is difficult.

Today's system is characterized by:

- Different types of computers and software in each air traffic control subsystem

- Different types of controller consoles and display equipment in each en route and terminal facility

- Multi-layered, overlapping coverage of navigational aids, communications sites, and surveillance facilities

- Large number of individual ATC facilities with the accompanying overhead costs

- Large number of leased communications lines and equipment

- Extensive supply, training, and technical support facilities

- Vacuum tube-type electronic equipment and its associated high operations and maintenance costs.

Some of the specific objectives of the Advanced Automation System [20] include:

- Improving safety by reducing risks of mid-air and surface traffic collisions, landing and weather-related accidents, and collisions with the ground

- Increasing controller productivity

- Accommodating increasing demand on the system

- Allowing the users to operate with a minimum of constraints and with fuel efficiency

- Creating a more cost effective system through better use of facilities and equipment.

Thus, the environment for ATC by the year 2000 will be a modernized facility using state-of-the-art equipment and procedures designed to enhance the performance and productivity of the controller work force. Figure 2.3-1 provides a pictorial summary of the system transition from today's facilities and major equipment systems, through the interim ISSS and TAAS segments, to the final full AAS implementation of ACCC in Area Control Facilities and TCCC in Airport Traffic Control Towers.

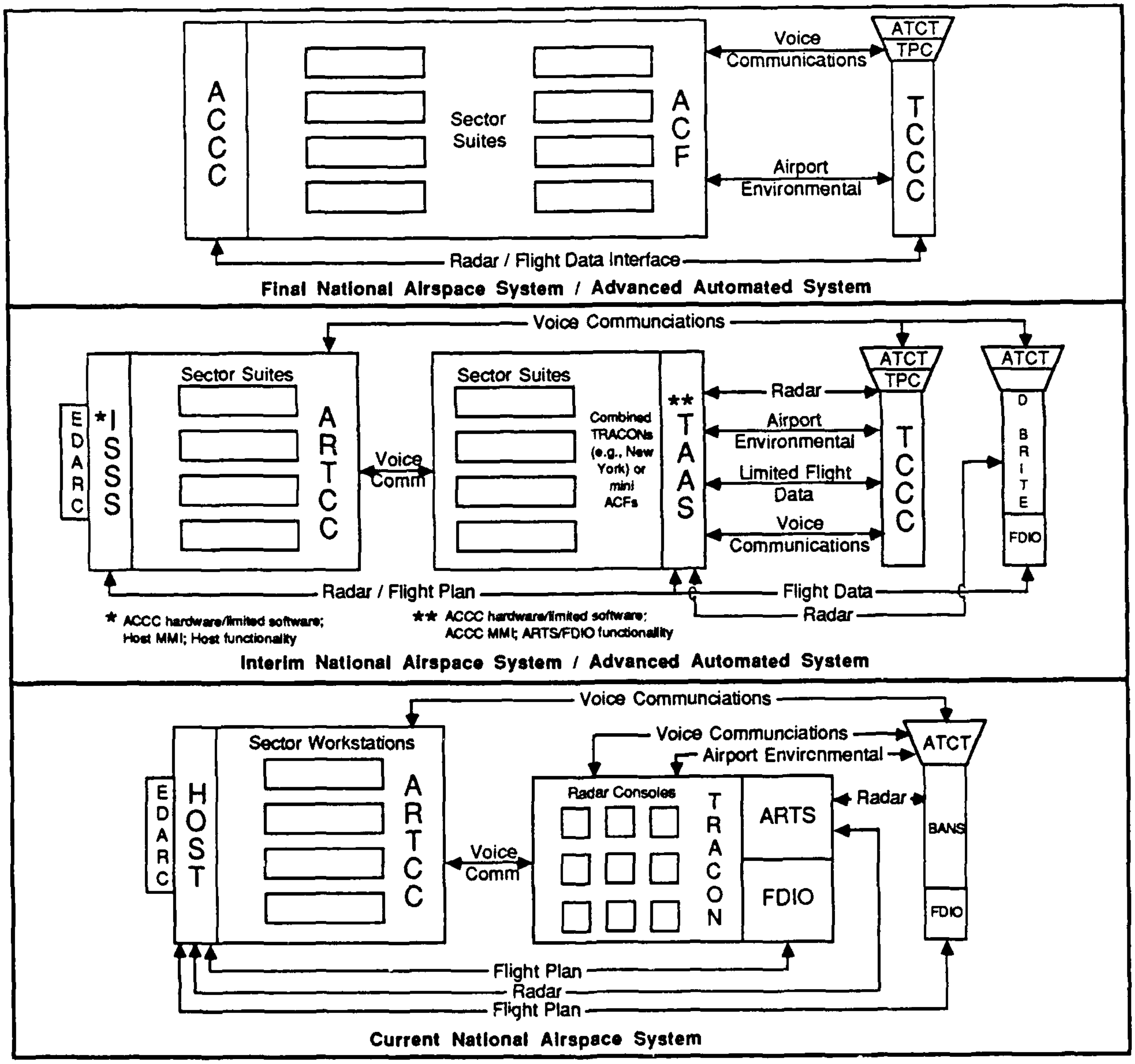


Figure 2.3-1. Pictorial Summary of NAS/AAS Implementation Stages

SECTION 3

METHODOLOGY

The Operations Concept development methodology begins by identifying and defining the air traffic events to which air traffic personnel respond. Responses to these events are then identified and decomposed to the task level. Analysis of the tasks thus identified, versus the automated system capabilities prescribed by the System Level Specification (SLS) [21], yields a thorough, detailed description of how the air traffic control job may be expected to be performed in the operational environment implied by the SLS. (NOTE: The methodology described here addresses the non-automated as well as the automated data handling asssociated with current ATC operations.)

The analysis rests heavily on information provided by active air traffic personnel with extensive knowledge and experience in the current system. Site visits to ATC facilities are major sources of data. Formal user-group review and validation of analysis results is an indispensable feature of the analysis process.

Figure 3.0-1 summarizes the analysis process. Information sources appear as square boxes on the left margin. Analysis results appear as square boxes in the right margin, annotated to indicate where they may be found in this document. The various steps of the analysis are shown as rectangles in the center of the figure. The figure shows the data flows among the various steps of the analysis. Each step of the analysis is annotated with the paragraph number in this section where the methodology involved is described in detail. User review is not shown separately in Figure 3.0-1 because it is integral to the entire analysis.

Maintaining the current status of the Operations Concepts reported in the data volumes is accomplished through a configuration management approach [16] that enhances their consistency and completeness when changes and updates to the data are necessary. This program is titled the Computer-Human Operational Requirements Analysis System. All task data are maintained in a computer data base. Relational data base programs automatically carry all task changes to every other task data table where those tasks are relevant. Information for task data tables is entered via preformatted task menus especially structured for each data table. Formatting for the printing of tables is carried out automatically, with appropriate data from other task tables included automatically, as appropriate. All of this greatly reduces the effort required to enter changes to the data base, and also reduces the opportunity for introducing human errors into the task data reporting.

3.1 CONTROLLER TASK MODEL

As Figure 3.0-1 suggests, the Controller Task List is the central analysis result. The logical decomposition of controller responses (or those of any other operational control position) to events ends at the task level, and for most purposes the linkage between controller needs and system functionality is most appropriately analyzed at the task level. The conceptual model of the controller task is based on the concept that operational actions of a controller are essentially of an information-processing nature. (NOTE: The term "controller" is used here and generally throughout the methodology sections in lieu of a position-specific term such as "en route controller." This is done to employ a generic term that is applicable to any operational position. In

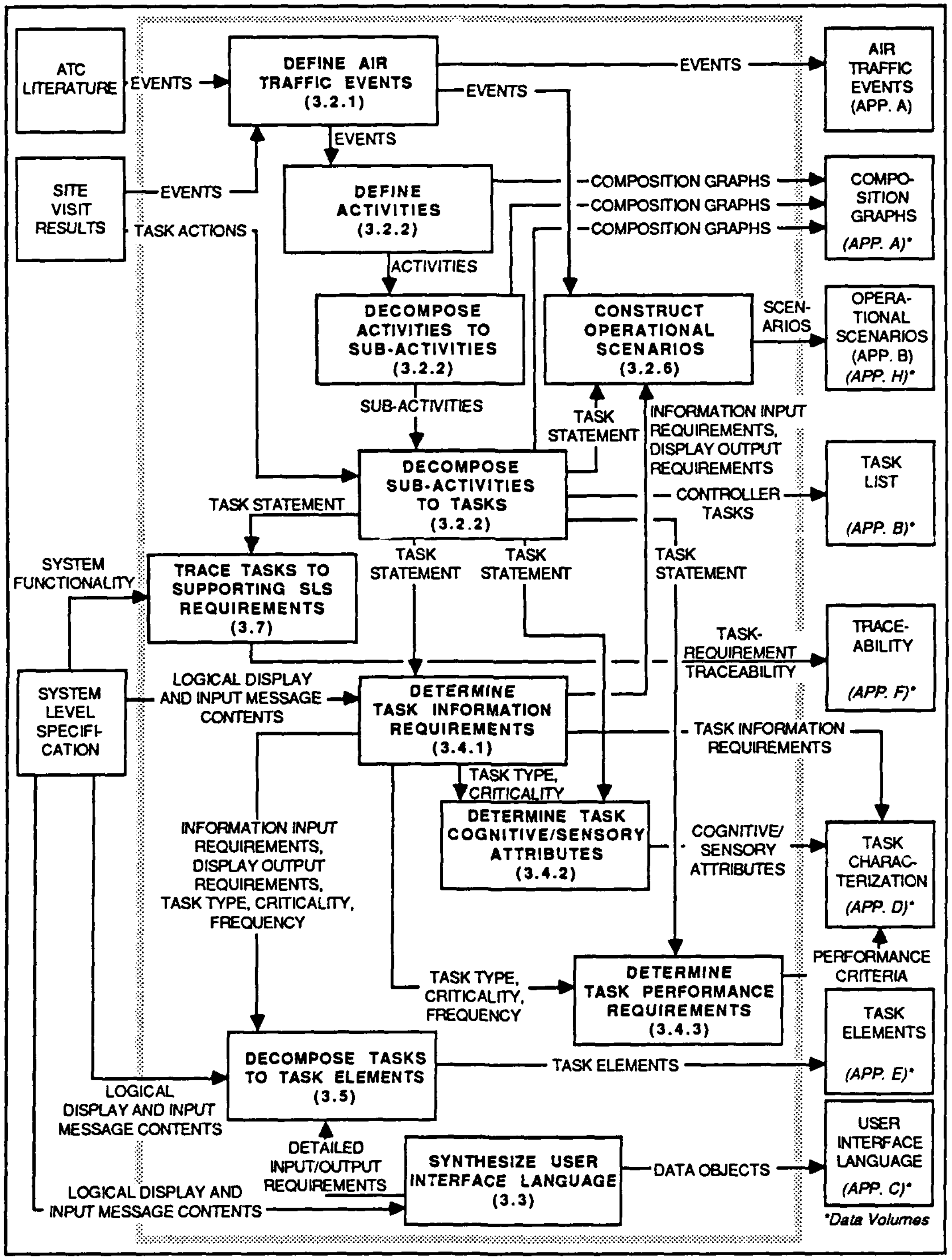


Figure 3.0-1. Operations Concept Analysis Flow

air traffic control, this includes several specialties of controllers as well as coordinators, supervisors, managers, etc.)

Each task is a meaningful unit of work performance, directed toward achieving an identifiable goal, and the tasks generally follow a pattern of input-process-output. Thus, the constituents of the Controller Task Model are:

a. *Air Traffic Events.* ATC personnel do not initiate actions (other than ancillary actions) unilaterally or independently in operational situations, but rather respond to events. An event may be an actual occurrence involving the interaction of aircraft, system parameters, facilities, equipment, and weather, such as a runway change or a flight plan deviation. Alternatively, an event may take the form of a system prediction of a future occurrence, such as a predicted aircraft conflict, which stimulates the controller to act in anticipation. In such cases the prediction itself is the event. In either case, the operator typically responds to an event stimulus in the form of a system output message or verbal report, rather than directly to the event. For instance, the controller cannot observe a changed sensor status directly. Instead, the changed status is reflected in the displays, or is reported by another person.

   Section 3.2.1 describes the derivation of the Air Traffic Events. The events are listed and defined in Appendix A to this volume.

b. *Global System Parameters.* Orders, procedures, directives, and other high-level prescriptive data provide the overall framework for operational actions and define the range of possible responses to an event stimulus.

c. *Human Performance Indices.* Certain cognitive and sensory attributes of the controller are typically involved in performing operational tasks. The extent to which a system's MMI design enables the individual to apply these attributes efficiently is one measure of its overall success. Performance criteria (time and accuracy) may also be applied as concrete measures of success in performing the task.

   The methodology for identifying cognitive and sensory attributes for the more critical tasks is discussed in Volume I, Section 3.4.2. Performance criteria methodology is discussed in Section 3.4.3. Data for both analyses appear in Appendix D of each data volume.

d. *Ancillary Actions.* Many actions a controller performs cannot be associated with specific events. For instance, applying or removing a longitudinal scale, range rings, or an alphanumeric tag are actions not performed specifically in response to any event. Such actions may, however, be performed at the controller's discretion, to support the performance of a variety of event-related tasks. These ancillary actions appear as display control manipulations in Appendix C, Table C-2, of the respective data volumes.

e. *Response.* The focus of the Task Model is the operator's response to the event stimulus. Within the bounds imposed by the global system parameters, the

response synthesizes the controller's cognition and use of relevant machine functions in an action directed toward an appropriate, meaningful closure condition. The response is in a form that can be evaluated against the applicable human performance indices. Ancillary actions may also be performed in conjunction with the response to an event stimulus.

The response is developed through the event-based Task Analysis. Methodology is discussed in Volume I, Sections 3.2.2 and 3.2.3;data appear in Appendices A and B of the respective data volumes.

f. *Task Closure*. In an operational situation, each task exhibits a definable closure condition. This closure condition is a meaningful, identifiable goal, which when met signifies that the task is complete.

Analysis of task closure conditions is not a separate part of the analysis. Task Closure is represented by the final Task Element (see Volume I, Section 3.4 *et seq.*, and Appendix E of the data volumes) and/or the transition to the next task as defined in the Composition Graph (see data volume Appendix A).

Figure 3.1-1 shows the relations among the constituents of the Controller Task Model.

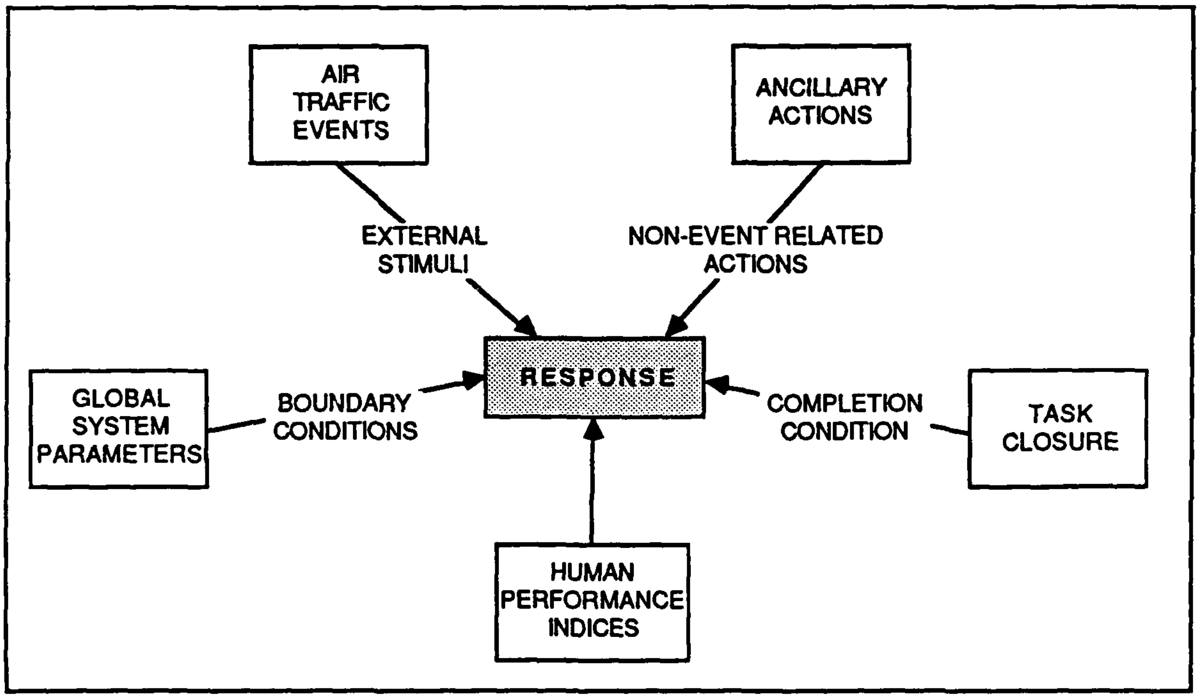


Figure 3.1-1. Controller Task Model

3.2 DERIVATION OF TASKS

The approach used to derive and document the Operations Concept for an operational position is based on data collection through document reviews, site visits, and performance observations.

To encourage consistency and completeness, a wide range of operational documentation is examined for impact on the specific operations of the position being analyzed. These documents collectively describe current and/or future system operations from a variety of perspectives. Taken together, these documents provide the framework for the development of an initial analysis of system events and controller tasks. This initial analysis is subjected to several later revisions as a result of site visits and user-group reviews.

The following documents have been reviewed as source material for Operations Concept generation:

a. For analyses of air traffic control operational positions, the following documents are prime sources of current event and task information for different operational positions:

- FAA Order 7110.65, *Air Traffic Control* [18]
- FAA Order 7210.3G, *Facility Operation and Administration* [19]
- FAA *Airman's Information Manual* [22]
- Facility Position Job Descriptions
- CTA CDRL A001, *En Route/Terminal ATC Operations Concept* [2].

b. The following documents describe aspects of future AAS systems and operations:

- *FAA National Airspace System Plan: Facilities, Equipment and Associated Development* [20].
- *FAA Advanced Automation System, System Level Specification, Acquisition Phase* [21]
- Reports and minutes of official FAA groups reviewing and validating various requirements and aspects of the future AAS system.

c. The following documents describe Operations Concepts and related analyses for operational ATC positions in the AAS:

- DOT/FAA/AP-84/16, *Operations Concept for the Advanced Automation System Man-Machine Interface* [6]
- DOT/FAA/AP-84/18, *Sector-Suite Man-Machine Functional Capabilities and Performance Requirements* [7]

- CTA CDRL A017, *Operations Concept for the AAS MMI: Oceanic and Supervisory Positions* [5]

- CTA CDRL A028, *Non-Sector Position MMI Language Requirements* [4]

- CTA CDRL A029, *Sector Suite/Operational Interface System MMI Language Requirements* [9]

- DOT/FAA/AP-85/06, *Revised SSRVT Operational Requirements Data* [8]

- DOT/FAA/AP-86/02, *Operations Concept for the TCCC Man-Machine Interface* [13]

- CTA CDRL D104, *TCCC Controller Task Element Statements* [14]

- CTA CDRL D105, *TCCC Supervisory Operations Concept* [15].

Previous analyses such as those cited above have been examined for operational tasks or job responsibilities implying operational tasks of the position of interest. Interactions of others with the position of interest are also reviewed to derive additional communication and information exchange tasks. If Position X has a task involving forwarding information to Position Y, then Position Y has a task of receiving such information, and vice versa. Also, existing analyses of related job positions provide a valuable source of task statements to incorporate in a survey form, which job incumbents can quickly scan and indicate which tasks they, too, perform. The respondents also can indicate changes in terminology as required to fit their own situations more accurately. Such survey forms are particularly useful when visiting facilities having small work forces, such as Towers, where it is difficult for workers to take enough time away from their jobs to be interviewed thoroughly. These survey forms also are useful in noting which particular positions at a facility tend to perform each task as part of their normal job assignments.

Visits to operational facilities provide an opportunity to familiarize analysts with actual real-time operations, observe controller performance of the job, interview controllers and/or their supervisors for job information, and collect data describing the operational environment and performance. Preliminary procedures include the development of data collection instruments for utilizing observational techniques, structured and unstructured interview techniques, and survey forms. Figures E-1, E-2, and E-3 in Appendix E portray examples of such materials for facility descriptions, event verification, and task relevancy, based on materials prepared for the analysis of Tower Controller positions and reported in Volume V.

An essential effort in development of an Operations Concept for an operational position, and for associated task analyses, is validation of the information by a user group representing the population of controllers and their supervisors. This group is composed of experienced personnel from a variety of facility backgrounds and geographic locations, who also are familiar with the intended future system, as described below in Section 3.6.2.

As is noted above in Figure 3.0-1, the analysis process begins with the identification and definition of the system events to which individuals in an operational position assignment respond. Controller response to an event, or set of related events, are successively decomposed to the **activity** level, to the **sub-activity** level, and to the **task** level of a controller action statement. The Composition Graph technique is used as the decomposition tool for controller actions because it is capable of providing both the logical rigor needed for consistent and thorough decomposition, and the flexibility needed to capture the multi-processing nature of dynamic control and information-processing jobs. Sub-activities are directly traced to one or more system events. Thus, tasks within a sub-activity inherently are traceable to system events. "The advantage of employing this model is that a direct correspondence between system events and tasks can be maintained; accuracy and completeness are significantly enhanced, and derived man-machine interface requirements will be directly traceable to events" [27].

Composition Graphs of activities and sub-activities show the logical, sequential flow of controller actions associated with system events. Sub-activity graphs portray this flow of specific tasks in a general "input-process-output" sequence, consistent with the information-processing task model described above in Section 3.1. Decision points, iterations, and parallel conditions are included in the Composition Graphs as necessary to elucidate the logical task flow within the sub-activity. Situations can be presented where one or more of several paths may or must be followed almost concurrently, as is typical of many control and information-processing efforts. Figure 3.2-1 illustrates an example of the structure of a Composition Graph. Figure 3.2-2 illustrates the graphing symbology for decision points, tasks "borrowed" from another sub-activity (wherein the task is uniquely numbered within one sub-activity but is used in graphing another sub-activity with the original number retained), other individual positions or agencies involved in the task (when communication and coordination are involved), and the media by which information may be transmitted or received by the controller in the performance of the task. Since a task may appear in more than one sub-activity (or even several times in one sub-activity), the coordination information encompasses all cases; not all coordination points or media may apply in a particular occurrence of a task. Use of the Voice (V) media implies any voice communication, either via VSCS, TCS, or use of direct person-to-person conversation when the recipient is within hearing distance. Use of the Mail or Message (M) media implies either ATC Mail or General Information (GI) Message, as applicable for ISSS, TAAS, ACCC, or TCCC.

Unique identifiers are applied to activities, sub-activities, and tasks reflecting the operational position addressed and the item's position in the logical decomposition. The unique identifier is composed of several one-or two-digit fields, of which the first indicates the operational position and facility type. The following position/facility identifiers have been established:

A1 = En Route/Terminal Controller (ACCC, ISSS, TAAS)
T1 = ATCT Local Controller (Radar)
T2 = ATCT Ground Controller
T3 = ATCT Clearance Delivery/Flight Data Controller
T4 = ATCT Area Supervisor

The second field in the unique identifier denotes the specific **activity** of the position (e.g., A1.1, A1.2, etc.).

The third field identifies the **sub-activity** within the activity (e.g., A1.1.1, A1.1.2, etc.).

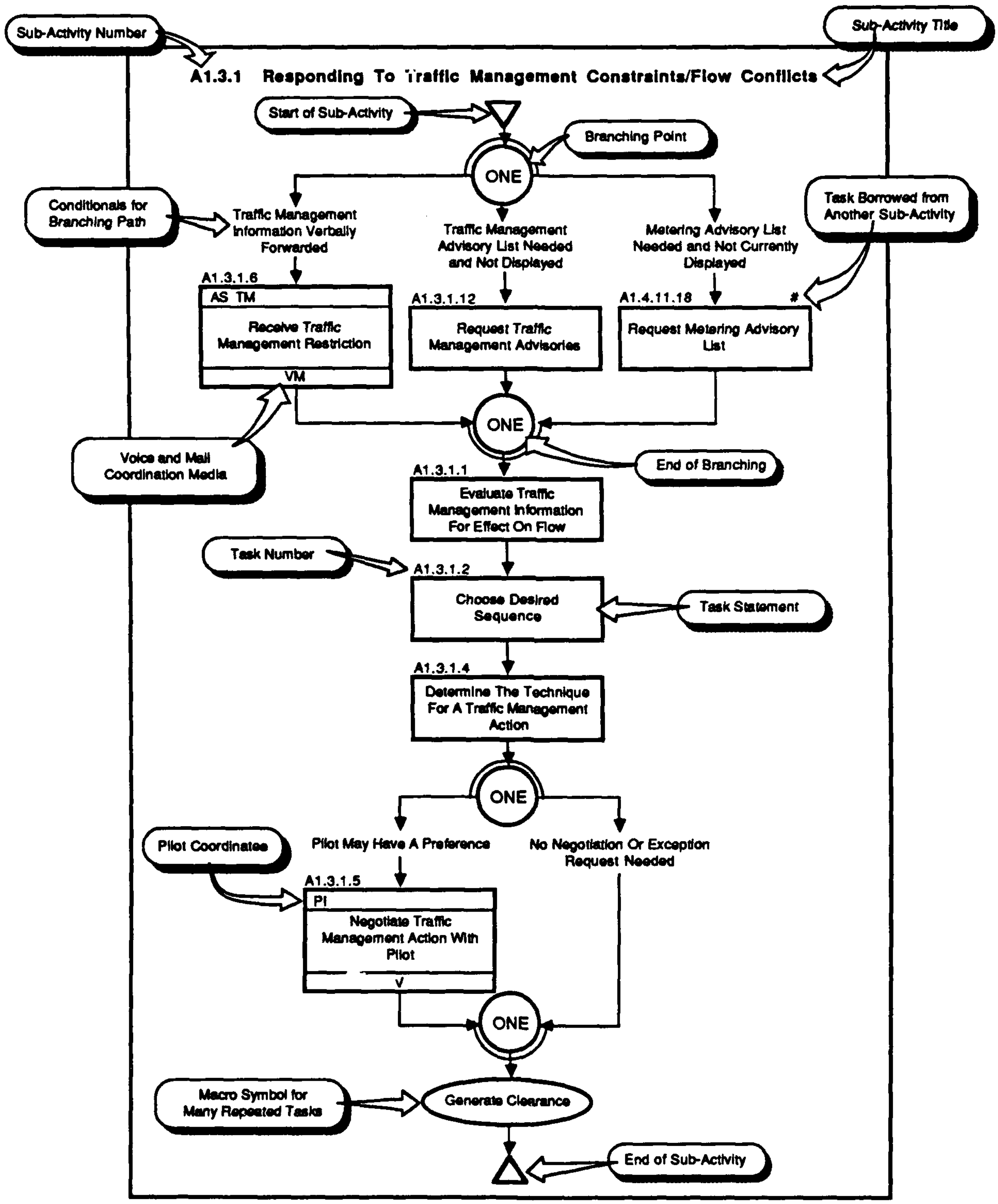


Figure 3.2-1. Example of Composition Graph Structure

Symbol	Meaning
COORDINATING POSITIONS / TASK STATEMENT / COORDINATION MEDIA; TASK STATEMENT #	Controller tasks, with and without coordination positions/media. Number symbol in upper right of task box indicates a task duplicated from another sub-activity.
SOME	SOME - Perform tasks or task sequences almost concurrently as required.
RPT	REPEAT - Perform tasks or task sequences continuously/repetitively as required
ONE	ONE - Perform only one of the alternative tasks or task sequences
▽ △	START/END
Generate Clearance	GENERATE CLEARANCE MACRO
Trial Planning	TRIAL PLANNING MACRO (ACCC only)

COORDINATION

COORDINATING POSITIONS/AGENCIES	COORDINATION MEDIA
CT - En Route/Terminal Controller	V Voice Communication (Interphone, A/G Radio, Direct)
AS - En Route/Terminal Area Supervisor	M Electronic Message (unstructured text such as ATC Mail or GI Message)
AM - En Route/Terminal Area Manager-in-Charge	F System Function Message (e.g., function key, structured text)
FS - Flight Service Station	A Automated Coordination (reserved for later use with AERA functions)
TM - Traffic Management Coordinator	
MC - Military Mission Coordinator	
AF - Airway Facilities/DSC	
MT - Meteorologist	
PI - Pilot	
TW - Tower Controller/Supervisor	
CF - Central Flow Control	
AR - Aeronautical Radio, Inc.	
BA - Military Base Operations	
OC - Other Coordination	

Figure 3.2-2. Composition Graph Symbology

The fourth field is the specific task number within the sub-activity (e.g., A1.1.1.1, A1.1.1.2, etc.). These unique action statement identifiers provide traceability throughout the logical decomposition and to the driving event(s). They also facilitate automated data storage, retrieval, and manipulation.

The numbering of ACCC tasks in Volume II serves as the baseline for numbering tasks in the other data volumes for en route and terminal controllers. If a task is performed in all phases (ISSS, TAAS, ACCC, AERA 1, etc.) without change, it is used in any Operations Concept work as is; i.e., same task number, same task statement, same elements, etc. If the task changes enough such that the elements (Section 3.5 and data volume Appendix E) will be different, then separate task numbers are identified for each version of the task. The task may keep the same statement (if it is still appropriate), but it will have a different task number from that used for the ACCC baseline. For example, a task such as A1.4.4.3, Enter flight plan, is performed in ISSS, TAAS, ACCC, and AERA 1, and beyond, but at some later time an enhancement is made which automates most of the manual data entry. The task statement "Enter flight plan" may be used for all transition states, but for the later stage the task number will be other than A1.4.4.3.

The second version of the task (in this example, the later time version) refers to the *whole* task as it is performed at that later time, not just to the part that is different from ISSS-TAAS-ACCC-AERA 1. In other cases, the statement of the task also may change. These changes are essential for several reasons:

- They are consistent with the definition of a task as a meaningful unit of work performance.

- They do not artificially make it appear to the reader that two tasks must be performed in parallel when there really is only one task being performed.

- They avoid the problem of what to do when the task evolves to a smaller, rather than to a larger, task.

For the sake of brevity, when a position performs a fixed set of tasks frequently in a number of sub-activities, a "macro" symbol is used in the Composition Graphs to represent that set of tasks. "Generate Clearance" is one such task set applicable to air traffic controller positions. "Trial Planning" is the label of another macro used in association with AERA 1 functionality. These macros are depicted as ovals on the Composition Graphs, and their component tasks are defined in the particular data volume where they are applicable. Examples of macro symbols used on graphs appear in Figures 3.2-1 and 3.2-2.

The Composition Graph technique does not require that any particular graph be followed uninterrupted to its conclusion. This is consistent with the nature of dynamic control and information-processing jobs, where a given activity, sub-activity, or task may be interrupted at any time by higher priority action, to be resumed later. Also, it is not a requirement of the Composition Graph technique that all possible tasks responding to a given event be portrayed in one sub-activity graph. The hierarchical nature of top-level position graphs (containing activity statements), activity graphs (containing sub-activity statements), and sub-activity graphs (containing task statements) provides the interconnectivity to link controller actions. Thus, one sub-activity graph for air traffic controllers pertains to the planning of clearances, and another sub-activity graph pertains to the issuing of clearances. These sub-activities are obviously related and sequential, and that

relationship would be depicted in their higher-level activity graph. Though a Composition Graph somewhat gives the appearance of a flow chart of operations, it represents state transition information rather than strict control flow.

A sub-activity Composition Graph reflects the linkages among tasks, not a hierarchical arrangement that implies the "level" of the task. Thus, the first task is not an "overall task" to be accomplished by performance of the tasks that follow on the graph. More often, the first task or tasks on a graph reflect the operator becoming aware of an event. Subsequent tasks then illustrate what the operator does or may do in response to that awareness. Thus, these "graphs show the logical decomposition of [operational] tasks and also illustrate the nature of the relations between tasks....[They] aid the task decomposition by visually illustrating the task flow, and are invaluable for expediting user [review and] validation" [27].

Upon completion and user-group validation of the Composition Graphs for a position, the tasks are listed sequentially by number and incorporated in Appendix B of the appropriate data volume. This task listing includes a summary of the coordinatees noted on the Composition Graphs and an indication of system transition stages to which the task is relevant.

The tasks then are subjected to a variety of analyses to characterize their nature and information content (Section 3.4). Tasks also can be decomposed further into their procedural steps and actions, called **elements** (Section 3.5). This is accomplished at a level short of specifying system design-dependent detail, but to a degree that provides operational insight to important design considerations and to essential job trainin, content.

The following sections discuss these techniques in more detail.

3.2.1 Events

The task analysis begins with identifying and defining the system events to which the controller responds. "Events" are distinct occurrences in the system which the operator perceives (either directly or, much more frequently, through the medium of a system display or message from another person), and responds to in some goal-directed manner.

For operational positions in air traffic control, Appendix A cites the events identified for en route, terminal, oceanic, tower, and supervisory operations. A single comprehensive event set serves as the overall basis for all operational positions, with new events added as required to suit analyses of additional positions or system transition states; some events are not applicable to some positions or transition states. System improvements such as those provided by the advanced automation functions may also require the definition of new events. In general, however, the event set shows relatively little change through the evolving AAS or among different positions.

It is helpful in identifying system events to devise top-level categories of such events. Appendix A describes categories used to identify air traffic control operational events. These categories assist in efforts to identify all the relevant operational events influencing a particular job or position.

3.2.2 Activities, Sub-activities, and Tasks

Activities, sub-activities, and tasks are three increasingly detailed levels of stating the work performance actions of a position or job.

Activities are the top-level operational job functions. Typically, five to nine activities cover all the operational duties of a position. Activity titles tend to be quite short, roughly following the statement structure of a "task" statement: (a) high-level action verb or verbs; (b) object of the action (stated in the plural); and (c) possible object or action modifiers. Activities serve to group the event-related "sub-activities."

Sub-activities state work performance actions at the next level of detail. Again, five to nine sub-activities typically constitute an "activity," though these numbers are not mandatory. Sub-activity statements generally follow the structure of task statements, with the action object stated in the plural. To differentiate this action level from the others, the initial action word(s) is stated in the gerund ("-ing") verbal noun form. Sub-activities are derived from one or more related system events, within the context of the associated "activity." Generally, the relation among the events associated with one sub-activity is such that the resulting task paths in the sub-activity's Composition Graph interlink at a common task at least once. That is, a sub-activity cannot be divisible into two completely independent sequences of tasks. However, some operator actions fitting the definition of a "task" do not necessarily relate to, follow, or precede other tasks. This occurs, for instance, in "housekeeping" tasks to clean up displays containing outdated or no longer needed information, or for various display or control adjustment tasks. For convenience and consistency with the Composition Graphs of other sub-activities, these may be displayed as a string of unassociated tasks, rather than merely listing these tasks under a "sub-activity" title.

Tasks are the foundation blocks of the work performance description. Their importance derives from their historical role as a level of job-oriented work action statement where analysts generally can agree on an action statement's level of specificity. Though there are many variations of the definition of a "task," it is possible to state such a definition in a manner that permits general agreement that a particular statement does express a "task" level of worker action.

For analysis purposes such as describing Operations Concepts or deriving performance-oriented training content, a "task" is a concise, specific statement of one purposeful job action of a worker, generally performed by one individual within some limited period of time. It is a **meaningful unit of work performance** in the context of a job position, having a discernible beginning and ending (such that a job incumbent can readily respond to a question of *how often* that individual performs the task). Thus, tasks are intermediate in specificity between the high-level activities/sub-activities and the procedural steps and actions (i.e., elements) by which they are accomplished. Tasks are stated at a functional level of *what* is accomplished by the controller, not precise procedures or steps of *how* that work is performed on a given set of equipment. Their intent is to reflect what gets done without unduly restricting them to a particular equipment design, display type, or specific procedure.

Tasks are stated with an action verb, object of the action (the item acted upon), and any modifiers necessary to provide clarity and discriminability from related or similar actions. Verbs are stated in the first-person singular form. Objects usually are stated in the singular, unless the action necessitates the plural (e.g., Wash the office *windows*). Descriptive statement modifiers take one of four forms:

- Stating the action's purpose or objective. (*WHY*)
- Stating the means or media. (*HOW, WHICH WAY*)
- Stating the scope of the action situation. (*RANGE, RESTRICTIONS*)
- Stating the conditions to the action. (*WHERE, WHEN*)

Reference Figure 3.2-3 for illustrations and descriptors of information-processing tasks.

Multiple verbs and objects are permissible in stating tasks only when they are all accomplished as part of the task each time the task is performed. There should be no confusion in being able to quantify how often the task is performed. Multiple verbs also may be used for clarity when they are synonymous, as when different groups or persons holding the same position employ different terminology for the same action. Tasks involve controller interaction with such objects as displays, equipment controls, other people, messages, ideas, data, and conditions. Machine functions and responsibilities of teams, agencies, facilities, or the equipment system are not tasks. Tasks are actions of individual people, not of organizations or equipment.

Concise, But Specific, Statement of a Purposeful Job Action

ACTION VERB	+ ITEM ACTED UPON	+ MODIFIERS TO CLARIFY
E.G., Check Compare Determine Estimate Identify Inform Judge	• Things (Controls, etc.) • Data/Concepts • People	• Purpose/Objective (Why) • Means/Media (How, Which Way) • Scope of Situation (Range, Restrictions) • Conditions (Where, When)

Figure 3.2-3. Information-Processing Task Description

Action verbs for ATC tasks are defined in Appendix C. Other verbs are defined as needed for description of additional ATC positions. Some general statements of task objects (e.g., weather information) may tend to mask the object specifics (e.g., wind shear information). The reader should refer to the User Interface Language contained in Appendix C of the data volumes for the components of task objects.

Tasks appear within the flow of a Composition Graph in the general sequence from top to bottom to reflect INPUT to PROCESS to OUTPUT. Thus, there are three general varieties of tasks:

- Tasks to gather or receive information. These usually are of a verbal or sensory nature. *(INPUT)*

- Tasks for determining or assessing a situation or state of affairs. These usually are of a cognitive nature, though occasionally they are verbal. *(PROCESS)*

- Tasks to act upon or control a situation or state of affairs. These usually are of a verbal or motor nature. *(OUTPUT)*

These three forms of tasks would appear in sequence in a simple, straightforward sub-activity, not involving complex and extensive responses to an event stimulus. Exceptions also may occur to these sequences based on particular job contexts and situations.

Tasks may be characterized as predominantly Sensory (perceptual), Cognitive (mental), or Motor (voice, tactile) processes. However, many tasks are a composite of several of these processes, as noted in the characterizations of task type (Section 3.4.1) and description of the task elements (Section 3.5). An individual task may incorporate multiple aspects of sensory, verbal, cognitive, and motor features and actions, though the action verb that is used may infer only one of these as predominant. **It is necessary to view a task in the context of its sub-activity Composition Graph to fully infer its task types and the component types of element actions.**

The process of decomposition from activities to sub-activities to tasks preserves the transitivity of traceability between the event stimulus and the resultant response of the operator.

3.2.3 Guidelines for Deriving Tasks and Stating Task Information

An Operations Concept is intended to show how the operator position being analyzed may be expected to perform operational duties and actions in a particular system (either current operations or some future enhanced system such as ISSS, ACCC, AERA 2, or other), given that the system provides for the functionality called for in the applicable System Level Specification. Additionally, for the development of Operations Concepts for different transition states in systems subject to a series of equipment and software enhancements, there is a need to assure consistency and compatibility among the several possible Operations Concepts. The resultant task analyses, therefore, should produce task statements that meet these goals:

- Consistent in scope and level of detail.

- Stated at a level appropriate to provide visibility into the specific features of system functionality involved in each task, without implying specific design features.

- Stated at a level that facilitates user-group validation of Composition Graphs and tasks: neither at such a high level as to obscure important details of the controller-machine interaction, nor at such a low level as to bog down the reviewer in excessive detail.

- Consistent in their treatment of controller inputs to the system, outputs from the system to the controller, and cognition (not involving operator interaction with the system) on the controller's part.

- Consistent among themselves and with other documentation in their use of terminology.

- Clear in their distinction between different system transition states.

The following guidelines have been developed to help achieve the above objectives, particularly as the analyses relate to the present concerns for Operations Concepts of the FAA Advanced Automation System and subsequent enhancements:

a. It should be possible to perform most tasks (except extensive data entry of system function messages and some analytical tasks involving the integration of many data objects) in 3 to 8 discrete procedural steps (i.e., Task Elements; see Section 3.5). A Task Element here is *a single identifiable step in performing the task*, stated at a level of detail consistent with the language in a System Level Specification, and using the established Element Verb Taxonomy (Section 3.5.2 and Appendix C). This does not mean that Task Elements are to be traced to the System Level Specification, nor that the maximum number of Elements composing a task should be limited to eight. For some few tasks there may only be one or two procedural Elements. One special circumstance needs to be noted:

    - There may be alternate means of performing a task, involving optional Elements or alternate sequences of Elements, as in coordinating via a voice system (VSCS, TCS, or direct), electronic text message (ATC Mail or GI Message), or use of a system function or automated message. In most such cases, it usually is possible to perform the task, by choosing one media path or another, in 3 to 8 steps.

b. Traceability to System Level Specification requirements is performed at the Task level, rather than to Task Elements (see Section 3.7). If the task involves a system function input message, it must be clear from the task statement what system functionality is involved. If the system functionality is not clear from the task statement, the task is probably stated too broadly or is poorly written.

c. A task whereby the controller requests a display or display item should be balanced by a task to suppress that display, unless such display is subsequently suppressed automatically.

d. The scope of a task may change from one transition state to the next because changes in system functionality change how the controller performs the task, or alters what data are required to perform the task. Separate task numbers with appropriate transition state indicators must be employed if a change in the task is evident at the Task Element level; the task statement should be retained unchanged, if still applicable, to provide traceability from one transition state to the next. Changes too small to be evident at the Task Element level should be ignored, as the Task Elements are the finest granularity of analysis performed in the Operations Concept.

e. Two task-level action statements usually should not be derived if one of them follows automatically and immediately from the first, because the one typically is merely an Element of the other. For example, "Request display of a Special List" should not be followed by "Receive display of a Special List" as a separate task. It is assumed that the system will respond as requested, and the "receive" action should appear as the last Task Element of the "request" task. On the other hand, examining a requested display can be stated as a separate task because such action does not follow automatically after the request (i.e., need not be performed immediately after the request), or even may be performed without making a display request if the display is already present. Thus, "Request Weather Display" may be followed by "Evaluate weather situation for flight conditions."

f. Task statements should be detailed enough to stand alone, and not depend on their sub-activity context for meaning. In subsequent task characterizations (Section 3.4) each task is listed in tables, and all of their sub-activity contexts may not be identified. Also, tasks may be used in survey forms where their performance context is blurred or lost.

g. Purely cognitive or analytical tasks (e.g., "Determine need for a Trial Plan) should be derived to reflect where significant mental actions (evaluations, assessments, decisions) occur, but only where such cognitive action is deemed significant. No controller task can be performed without any thought at all. Even a simple situation such as "Receive system status information" implies the controller understands the transmitted information. However, identifying cognitive tasks where relatively little cognition occurs obscures the situations where cognition is significant, and unnecessarily complicates the task analysis and user-group reviews. The decision as to whether the cognition involved is "significant" is necessarily somewhat subjective, but subject to user-group review and validation.

h. Cognitive tasks where decomposed to their Task Elements should address the complete cognitive process. If, for instance, a decision involves evaluating data presented on one or more displays, it is insufficient to derive a number of separate Elements to obtain necessary information from each display. Integrating the data from the various displays to make the decision also is important. The Task Elements should reflect integration of information in performance of the task.

i. In evolving systems where source documents use different terminology for the same thing, the terminology of the latest version of the System Level Specification should be used in the task analysis, though task statements themselves are not

bound to official terminology. It is essential for task statements to be clearly understandable to user-group representatives reviewing or responding to the task statements.

j. In deriving tasks for a position, exception conditions must be accommodated, within reason. Profusion of extremely uncommon situations and tasks for a system designer to account for may undesirably bias the design, as well as confuse the user-group reviewer. Thus, it is appropriate to exclude such matters from the task analysis, unless the situation is of such overriding criticality to system operations when it occurs that it is essential to accommodate it in system design. One useful rule of thumb for excluding a rare control action is that the task action is performed less than once a year per individual controller.

k. Separate tasks need not be derived solely to distinguish different modes of coordination by transmitting information to specific recipients. In the Advanced Automation System for air traffic control, at least four possible modes of inter-position coordination within a single task will be available: Voice (VSCS, TCS, direct), Electronic Text Message (ATC Mail, and GI Message in early stages), System Function Message (such as handoff requests and responses), and Automated Coordination (in AERA 2 and subsequent enhancements). Advanced communication features such as Automated Coordination cannot be expected to supersede the former modes of coordination completely, because of the need to accommodate controller preferences and exceptional situations.

3.2.4 Task Verbs

Action verbs for use in stating tasks need to be carefully selected and defined to assure clarity of task expression and effective communication of the task action. It is essential that their meaning be clearly understood by user-group reviewers of the Operations Concept. This necessitates that some action terms employ terminology used on the job, unique to the job or position being analyzed and not in common usage by the general public. Effective communication to system designers and engineers also is necessary, requiring that the task verbs be selected for clarity of expression and fully defined to convey their intended meaning.

Though there is no set limit on the number of action verbs allowable for use in any one Operations Concept, communication and understandability are enhanced when the number of defined terms are kept to a minimum, consistent with the need to communicate operator actions effectively. To this end, synonymous terms are minimized or eliminated from the pool of defined and usable verbs for a position. Odd usages are to be avoided.

In stating tasks, a distinction generally is made between "*what the controller does*" and "*what gets done*." Statements of what the person does are called "worker-oriented" statements, and these are more appropriate for the description of Task Element procedures. Statements of what gets done are called "job-oriented" statements. For the most part, tasks should be "job-oriented" (or goal-oriented), providing a more functional description of "what" gets done without specifying "how" that action is performed by the individual. Task action verbs need to be selected with these considerations in mind.

Some task statements (and their associated action verbs) can imply both a worker and job orientation. In other instances the statement of a job-oriented task, through a reader's familiarity with the action, will readily imply a well-defined notion of what the controller actually is doing. The distinction between job- and worker-oriented actions (and task verbs) need not be emphasized too rigidly, but should be of general guidance in stating tasks and identifying allowable task verbs. The distinction is conceptually complex, and not readily applied in all instances.

Sixty-nine task action verbs have been identified and defined for stating operational air traffic control tasks for the National Airspace System. These verbs and their definitions are contained in Appendix C. They represent a composite of those defined previously for ACF/ARTCC sector controllers, ACF oceanic controllers, ATCT controllers, ACF supervisory personnel, and Tower supervisors. The definitions are not specific to any particular ATC position, but are generally applicable.

Fifty-two of the task verbs in Appendix C are generally applicable terms, suitable for use with tasks of many jobs interacting with computerized workstations and communications. Seventeen of the action verbs are specific to ATC operational terminology. These are marked with an asterisk in Appendix C.

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3.2.6 Operational Scenarios

The Composition Graph technique, described previously, provides a rigorous means of analyzing the controller's responses to particular events in successively finer levels of detail. Responses to each event are viewed in isolation from other events. In a real situation the controller is often required to respond to several events concurrently: one aircraft may be in transition status entering the sector, while another is in transition status leaving the sector, while a third wishes to file a flight plan amendment, etc. The operational scenarios described in this section integrate a variety of events and the controller's responses to them into a coherent, realistic whole.

Seven baseline scenarios are developed here: one each for a high-altitude en route sector, a Terminal departure sector, a low-altitude en route sector, a Tower local position, a Terminal arrival sector, a Tower ground position, and a Tower clearance delivery/flight data position. Each covers a 30-minute time block and includes descriptions of the background conditions and scenario activity. Scenario activity includes routine activity, which proceeds at an approximately constant rate throughout the scenario except as described below, plus other activity overlaid on the routine activity. Routine activity and other activity are presented as situations calling for controller action, the precise action taken in each situation to be determined by further analysis. The relevant air traffic event(s) also are identified for each scenario situation. The scenarios are to be viewed as independent, although they deal with a common set of fictitious sectors and Towers: activity in one scenario has no bearing on any of the others. The scenarios are described at the sector/Tower level for consistency with other Operations Concept work.

The designations of **"routine"** and **"other"** are not to be interpreted as equivalent to low and high criticality. Routine activity deals with maintaining safe separation of aircraft, which is the controller's primary responsibility. The term "routine" means aircraft are in conformance with their flight plans and current clearances, are being handed off properly from sector to sector, and are displaying no abnormalities. The bulk of traffic falls into this category in the current system and is expected to do so in the future. It requires less of the controller's time per aircraft than other traffic, but is of no less importance. "Other" refers to anything that is not routine, i.e., anything out of the ordinary, whether it is as critical as the routine activity, more critical, or less critical.

As stated, the scenarios portray realistic situations. There is a difference between "realistic" and "real." None of the scenarios are real. It is unlikely that all the activity included in any of these scenarios would occur in any 30-minute period in any single sector or Tower, and the sectors and Towers themselves are fictitious. However, it would not be unlikely to find actual instances of any two or three successive scenario situations from time to time somewhere in the ATC system.

Thus, the scenarios may be viewed as aggregations for analysis purposes of a number of micro situations into a single macro scenario. Figure 3.2-4 illustrates this concept.

In a real-world situation, a moderate workload for a typical controller is represented by a normal rate of routine activity, plus occasional occurrences of less demanding types of "other" activity. There are occasional spikes where the workload may increase sharply but usually briefly as more demanding "other" activity occurs; however, large, sustained variations in the workload are relatively infrequent in a normal situation. In each scenario the "routine" activity is considered to represent a realistic level of such activity in the current (1987) environment, for a typical sector/Tower of the type portrayed. Levels of routine activity are based on controller experience rather than rigorous quantitative analysis. Routine activity is assumed to proceed at the constant rate specified in the Routine Activity description for each scenario, unless some item of Other Activity impacts the rate of occurrence of Routine Activity. For example, a runway closure (an item of Other Activity) may force a reduction in the rate at which aircraft arrive at or depart from an airport (under Routine Activity).

The rates of occurrence of any particular type of "other" activity should not be construed as representing real-world conditions. However, the maximum "other" activity is indicative of real-world conditions. Since most real-world "other" situations occur infrequently and are of brief duration, there are rarely more than one or two "other" situations in progress at once. The scenarios reflect this limit on the maximum amount of concurrent scenario activity. Unlike the real world, the scenarios include few long periods without any "other" activity. Thus, the total amount of activity in each scenario is very high for the 30-minute time period covered, while the average controller workload on a minute-by-minute basis is considered moderate to high in the current environment. (Workload is a function of individual capacity as well as rates of occurrence of events; thus, the workload is considered moderate to high for the "average" journeyman controller.) The scenarios are not intended to test system limits in the present system or at any phase of AAS evolution.

In selecting events and constructing situations for these scenarios, emphasis is placed on situations involving (or potentially involving) substantial interaction between the controller and the automated system, or between the controller and others via the automated system. The scenarios do not include examples of every possible event, but each scenario includes a representative sample of events appropriate to the sector type, and at least one event from each event category (see Appendix A) appears in one or more of the five scenarios. Thus, the scenarios present an overview of the application of major MMI features in realistic situations.

These *baseline* scenarios are documented in Appendix B of this volume. The material in Appendix B includes descriptions of background, routine activity, and other activity in time-ordered sequence. The scenarios are *expanded* in Appendix H of each data volume, by analysis of the data from Appendix B versus the Composition Graphs, task list, and Task Information Requirements (documented in Appendices A, B, and D of the data volumes), to show in detail how the controller might respond under each applicable scenario during successive phases of AAS evolution.

Identifying the specific tasks in the expanded scenarios is a three-step process: first, the situation is analyzed to determine the event(s) implicit within it; second, the Event-Sub-activity Matrix (data volume Appendix B) is consulted to identify the sub-activity(s) that may be performed in response to the event(s); and third, the specific tasks appropriate to the situation are identified

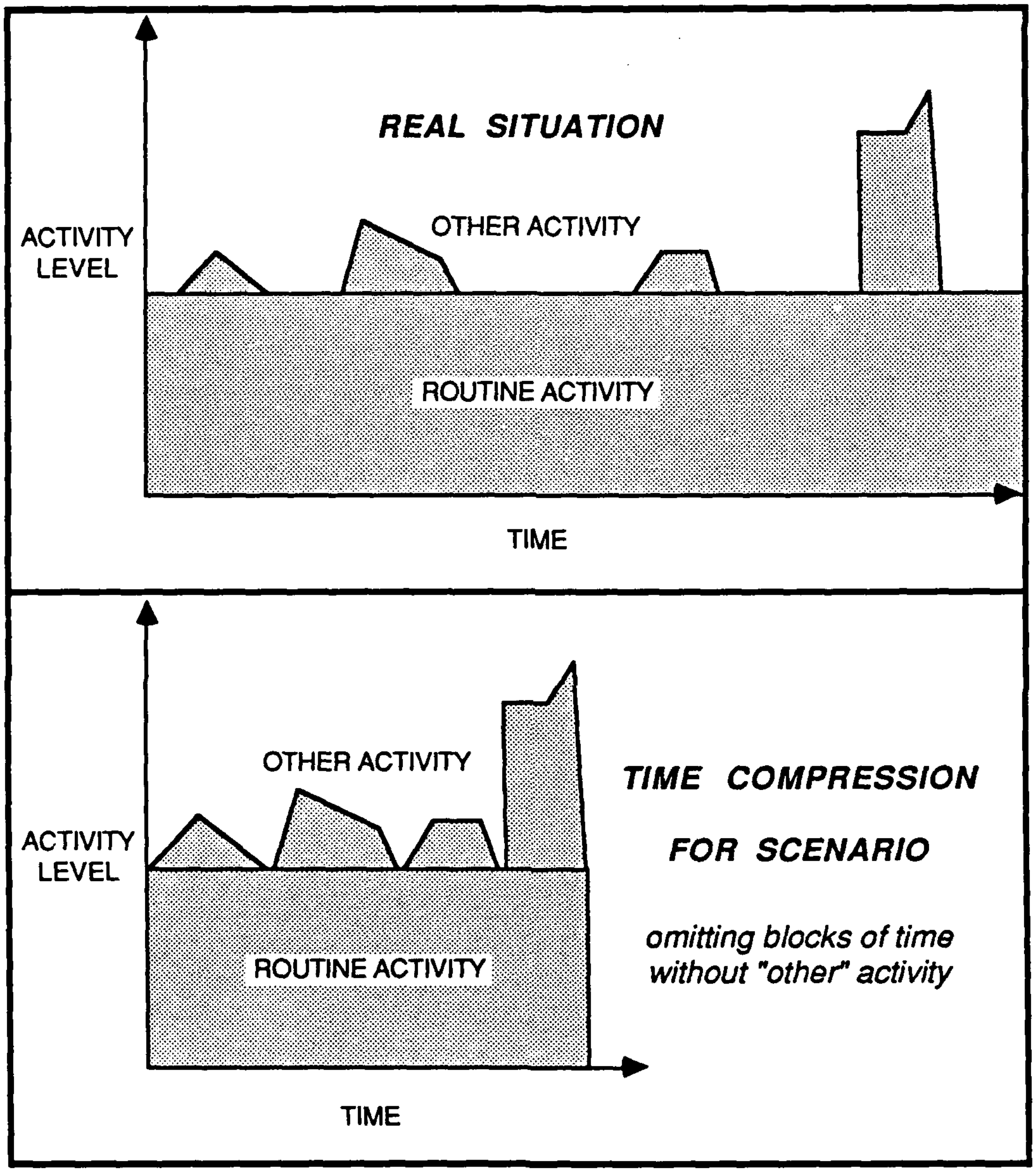

Figure 3.2-4. Operational Scenario Activity

within these sub-activities. Since the Event-Sub-activity Matrix contemplates many other possibilities besides the specific scenario situation, not all sub-activities related to a particular event in the matrix may be referenced in response to a particular scenario situation. Likewise, the specific data items identified in the expanded scenarios are selected from the Task Information Requirements analysis as appropriate to the particular scenario situation.

The baseline scenarios in this volume may be thought of as presenting series of problems for controller resolution; the expanded scenarios in the data volumes present a solution for each problem. Generally the details of the solution could vary, depending on complications introduced by parameters not specified in the situation description, or individual controller preferences. For example, local procedures might or might not require entry of a Flight Data Entry Notation (FDEN) in a particular situation, or (in AAS/AERA 1 and beyond) clearance generation might or might not be preceded by trial planning. In such cases the expanded scenario presents one realistic solution to the problem--not necessarily the simplest, most typical, or most complex possible.

The time required to respond to a scenario situation in context with other activity is estimated based on controller experience, not quantitative analysis. A reference number is appended to each scenario situation to help the reader track between the baseline scenarios in this volume and the expanded scenarios in the data volumes. Some reference numbers appear more than once, as some situations enter the scenario more than once.

As indicated above, the immediate purpose of the scenarios is to provide insight into the application of AAS functionality, in realistic situations involving multiple types of concurrent activity, at the sector/Tower level. The scenarios have other potential applications as well. Comparison of the scenario results from different data volumes could provide visibility into productivity gains accompanying each AAS phase. Performance under different loading conditions could be assessed by varying the rates of occurrence of scenario activity (e.g., one aircraft entering the sector every 30 seconds instead of every 60 seconds). The effects of different personnel/equipment configurations (e.g., one-console operation, two-console operation, sectors combined, auxiliary display available or not, or Tower operation with varying crew compositions) could also be assessed by specifying appropriate additional constraints on the scenario background.

The events and situations portrayed in each baseline scenario are selected to be representative of meaningful instances requiring controller interaction with the workstation controls and displays. They provide an opportunity in system demonstrations for controllers to exercise several system input messages and to observe system displays, outputs, and responses to those inputs. They represent but one sample of such events and situations. As such, other events and situations may be substituted in the baseline scenarios as needed or desired to exercise other system input messages and responses to other events. Refer to Appendix A for the complete list of possible system events that could be sampled. Appendix C of the pertinent data volume identifies the system input messages available to the controller. Thus, it becomes possible to exercise an array of workstation features and functionalities that may be of interest.

3.2.7 Task Coordinatees and Coordination Media

A controller may have to communicate or coordinate with other positions in the execution of a task. These other positions are referred to as coordinatees and include positions such as pilot, meteorologist, etc. Coordinatees for ACCC, ISSS, and TAAS are identical. Coordinatees for the TCCC are different.

Controllers may use any of three coordination media to communicate/coordinate with other positions. A fourth will be added with the advent of AERA functionality

- Voice: VSCS, TCS, or direct.

- Function: Computer system function message.

- Mail or message: Electronic text via G.I. Message or ATC Mail.

- Automated: Reserved for later use with AERA functions.

Figure 3.2-5 depicts the top portion of a typical Task List data form showing how coordinatees and coordination media data are represented in Appendix B of the data volumes.

Task Number	Task Statement	Coordination Media				Coordinatees														Transition State						Revision Date
		Voice	Function	Mail	Automated Coord.	ISSS/TAAS Controller	Area Supervisor	Area Manager	Flight Service	Traffic Management	Mission Coordinator	Airway Facility/DSC	Meteorologist	Pilot	Tower Controller/Sup	Central Flow Control	Base Operations	Aeronautical Radio	Other Coordination	ISSS	TAAS	ACCC	AERA 1	AERA 2	AERA 3	
A1.3.2.4	RECEIVE CONTROLLER NOTICE OF AIRCRAFT FLIGHT PLAN DEVIATION	V		M		C									T											
A1.3.3.6	RECEIVE NOTICE OF AIRSPACE RESTRICTION/RELEASE	V		M		C	S				X			P	T											

Figure 3.2-5. Task List Showing Coordination Information

3.3 USER INTERFACE LANGUAGE

The User Interface Language (UIL) is comprised of:

- Logical Display Contents (i.e., User Display Language)

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- Input Messages (i.e., User Input Language).

Each of these forms a hierarchy of data objects.

Logical Display Contents refer to messages and information output at the position workstation to the controller. These messages and information are output in the form of graphic displays, alphanumeric tabular displays, and alerts/alarms or other signals for controller attention. Input Messages refer to data and control messages entered by the controller to the system at the position workstation. Input Messages include operational messages and system control messages.

The objective of the analysis and decomposition of input and output messages is to define the MMI data in a manner such that information coding requirements, input requirements, and information density can be linked both to tasks and to data items. A hierarchical schema has been defined such that logical displays are composed of composite objects, which reduce to sets of objects, which are constructed from primitive data elements.

A hierarchical format for illustrating the nested relations between displays and data objects for display contents is contained in Figure 3.3-1. A parallel format for input messages is illustrated in Figure 3.3-2. Data object hierarchies are constructed for both types of objects. Together, these form the User Interface Language (UIL), which completely describes the controller-system interface in terms of data items and their interrelations.

Both hierarchies employ the same notations to convey information about object interrelations and object characteristics. These notations are:

=	Is defined as	
or	=	Exclusive "or"
and	=	And
( )	=	Message items form a group
{ }	=	Multiple iterations of a message item. Numbers added in the form X{ }Y indicate at least X but not more than Y iterations of the message. By default, X = Y = no upper limit defined.
[ ]	=	Optional item (for display output messages, item is displayed or not displayed at operator's choice)
* *	=	Comment or note
@	=	Reference source.

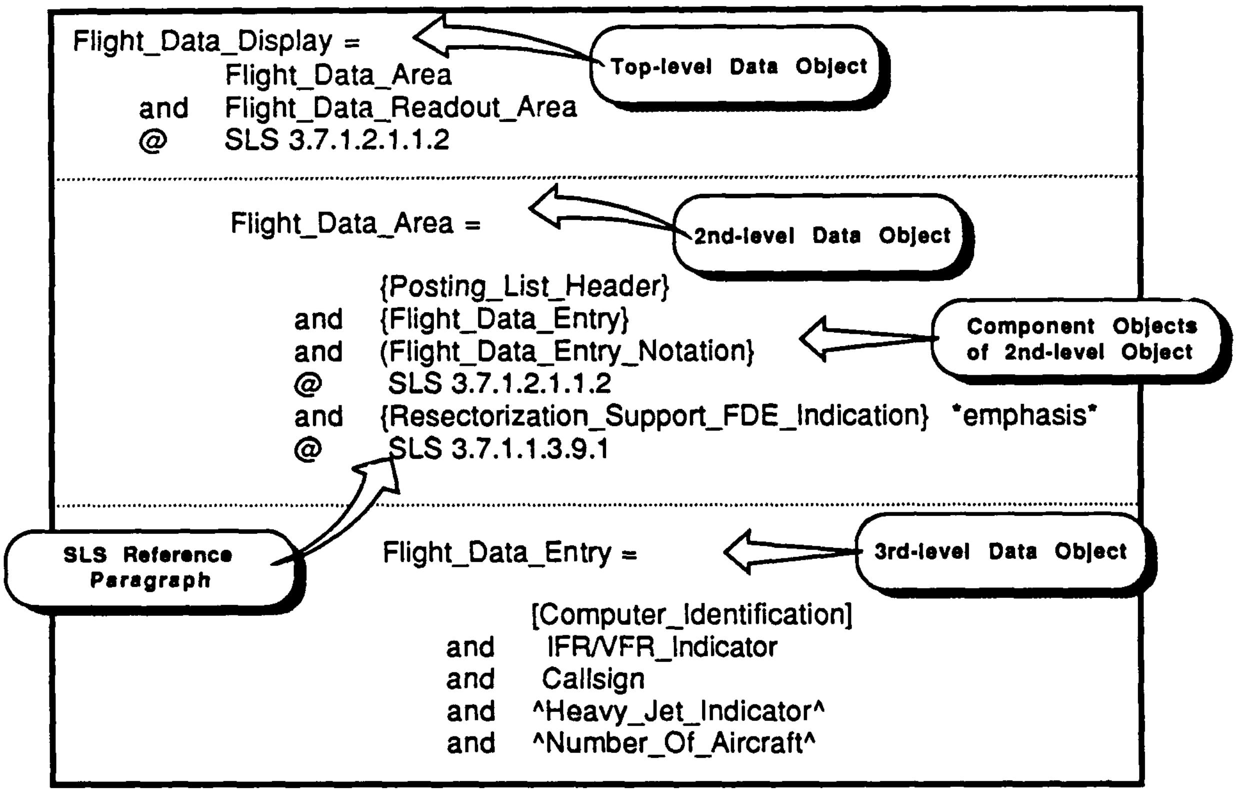

Figure 3.3-1. Logical Display Contents Illustration

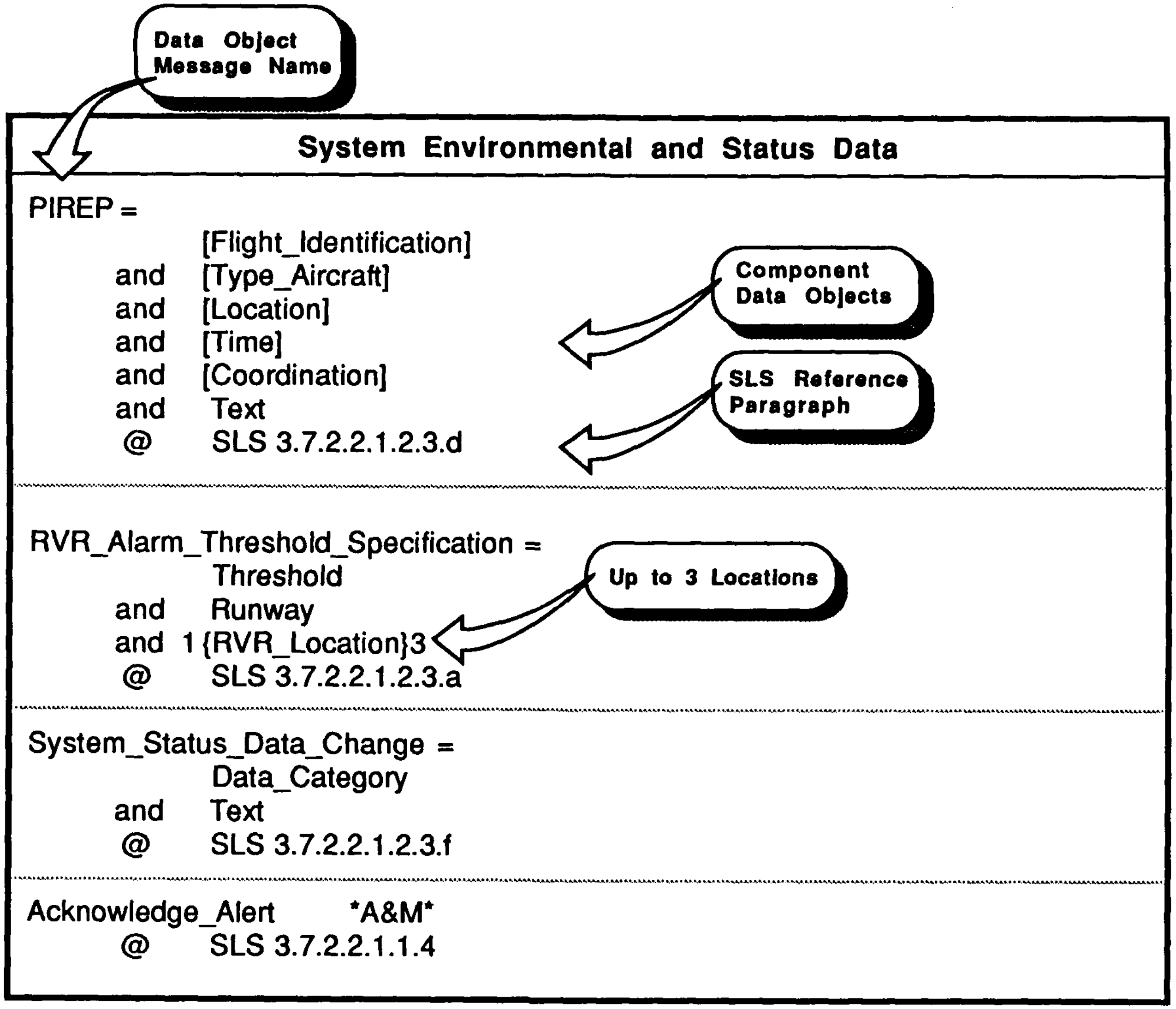

Figure 3.3-2. Input Messages Illustration

Additionally, Logical Display Contents employ one other notation:

^ ^ = Mandatory message item if applicable. If not applicable, there is no display.

3.4 TASK CHARACTERIZATION ANALYSIS

The relation between the task description (yielding Composition Graphs and task statements) and the various task characterization analyses is shown in Figure 3.0-1. Results of the task characterizations appear in Appendix D of the separate data volumes. Each characterization analysis is performed in the sequence noted below, building upon information generated in the previous analyses.

a. *Task Information Requirements* are identified for each task of a position. Here the task is characterized as belonging to one or more task types, and the information needed to perform the task is described. Both the requirements for information to be received by the controller from the system, and for information entered into the system by the controller are identified, using terminology previously identified and structured for the User Interface Language data objects (Section 3.3). Input and output messages for a position are listed in Appendix C of the relevant data volume. The display source of information received from the system is identified. For each task there is a rating (High, Medium, Low) of the typical frequency of controller performance of the task. Finally, the task is characterized according to its criticality (Extreme, High, Medium, Low), to identify those tasks for which rapid, accurate, and/or timely performance is most vital for safe and effective operations. Criticality is defined as the likelihood that failure to perform a task promptly, accurately, or in a timely manner will affect safe operations. The imminence of an effect on safety is not a consideration in assessing criticality.

b. Key human *Cognitive and Sensory Attributes* (or abilities) that are significantly involved in controller performance of a task are identified for the more critical tasks (i.e., task with High or Extreme criticality ratings in the Task Information Requirements). These human attributes are identified for a task based on the task type as developed in the Task Information Requirements, but are identified specifically for each critical task of a position. They provide further insight to aid in designing an effective MMI for the controller at the position workstation.

c. Critical tasks of a position are further characterized by identifying the *Performance Criteria* applicable to each. By identifying the performance factors that make a task's performance critical, this analysis indicates where automated assistance to the controller can be beneficial to overall controller (and system) accuracy and productivity. Very frequently performed tasks involving controller interaction with the machine system also could be subject to this analysis. As with the key cognitive and sensory attributes, the performance criteria are selected from among those appropriate to the task type, but are specified for each critical task.

Deleted.

The use of a limited number of formalized, well-defined, non-overlapping discriminators in each task characterization ensures consistency and reproducibility of results. Thus, for instance, only two possible Performance Criteria are defined for an Entry task: Accuracy of Entry and Implementation Time. Each system Entry task, therefore, can have Performance Criteria selected from only these two options.

Some characterizations, such as the criticality of a task, may be situation dependent. Therefore, rather than address the very large number of exception conditions that can exist in different facilities and different operational situations, the characterizations are developed in terms of a "generic" facility environment for the analyzed position.

This sequence of task characterizations continues the methodological process of gradual decomposition of a job from Events to Tasks to Task *Characterizations, producing subsequently* the Task Elements described in Section 3.5.

3.4.1 Task Information Requirements

Task Information Requirements are developed by associating controller tasks with direct observations and communications messages. Communications messages can be to or from a facility position, a computer display, or someone outside the facility (such as a controller or supervisor in another facility). Messages involving a computer display include controller-entered messages which may or may not update the machine data base, or computer output messages such as data blocks, weather, or status information.

The following are the components of the Task Information Requirements table, to be reported in Appendix C of the pertinent data volume:

a. *Task Type*: Tasks are categorized as belonging to one or more of four types:

- E (Entry): Entry of data into computer system (ACCC, TCCC, Host) by system function message or electronic text (ATC Mail, GI Message).

- R (Receipt): Receipt of information by means other than verbal communication (voice); includes system messages, electronic text (ATC Mail, GI Message), and direct observation.

- A (Analytical): Cognitive assessment and evaluation of data. Requires use of memory, problem-solving, or decision-making skills. Involves neither input nor output of information unless combined with another task type.

- VC (Verbal Communication): Transfer or exchange of information with another person or agency vocally via radio or phone (VSCS, TCS), or directly person-to-person when possible.

b. *Information Received by the Controller:* Information can be received via console display (including ATC Mail or GI Message) or (in the tower cab) via direct observation. Information received verbally is not recorded. The information contents are described as specifically as possible for each "Receipt" task. If the information is a data object of system output, terminology from the User Display Language (data volume Appendix C) is used. For some tasks, only a very specific data item is needed (e.g., Flight Data Entry). Other tasks may require reference to an entire logical or physical display. A levelling of information items is not possible or appropriate here. Comments located between asterisks (* *) are notations expanding upon or clarifying an information item.

c. *Information Source:* The source of the information received can be a specific workstation display, electronic message (ATC Mail, GI Message), or direct observation. This source for information listed as received is described. Verbal communication is not addressed. As with the Information Received (above), terminology in reference to workstation displays is consistent with the User Display Language (data volume Appendix C).

d. *Information Entered by the Controller:* Information entered by the controller via console data input to the system is described, for each "Entry" task. Terminology for system input messages is consistent with the User Input Language (data volume Appendix C). For information entered by electronic text message (ATC Mail, GI Message), only "ATC Mail" and/or "GI Message" is cited, since the contents of the electronic message have no semantic meaning to the system.

   Coordination by the use of unstructured electronic text messages (ATC Mail, GI Message) may be used only infrequently to communicate with collocated personnel, in very exceptional situations. Such messages may be viewed as a backup to voice communications, and as such should be included as Information Entered or Information Source.

   Where no information is received or entered in the performance of a task, the notation "N/A" should be entered in the appropriate table column or columns. See Figure 3.4-1 for a sample layout of the Task Information Requirements table. All information provided on this table is subjected to review by the user group, as are all other task characterization data.

e. *Frequency:* Tasks are assessed relatively against all other tasks of the position as having HIGH (H), MEDIUM (M), or LOW (L) frequency of performance.

E = Entry
R = Receipt
A = Analytical
VC = Voice Communication

E = Extreme
H = High
M = Medium
L = Low

TASK NUMBER	TASK STATEMENT	TASK TYPE	INFORMATION RECEIVED BY THE CONTROLLER	INFORMATION SOURCE	INFORMATION ENTERED BY THE CONTROLLER	FREQUENCY	CRITICALITY
T1.1.3.1.	DETECT EQUIPMENT STATUS ALERT	R	EQUIPMENT STATUS ALERT	ALERT AND RESOLUTION DISPLAY, SYSTEM ENVIRONMENTAL AND STATUS DATA DISPLAY	N/A	L	H
T1.1.3.2	ACKNOWLEDGE ALERT	E	N/A	N/A	ACKNOWLEDGE ALERT	L	M
T1.1.3.3	DETECT AERONAUTICAL AND METEOROLOGICAL ALERT	R	AERONAUTICAL AND METEOROLOGICAL ALERT	ALERT AND RESOLUTION DISPLAY	N/A	M	H
T1.1.3.4	OBSERVE DISPLAY OF NEW/ CHANGED SYSTEM STATUS DATA	R	SYSTEM STATUS DATA	SYSTEM ENVIRONMENTAL AND STATUS DATA DISPLAY	N/A	H	M
T1.1..3.5	OBSERVE DISPLAY OF NEW/ CHANGED AERONAUTICAL AND METEOROLOGICAL DATA	R	AERONAUTICAL AND METEOROLOGICAL DATA	SYSTEM ENVIRONMENTAL AND STATUS DATA DISPLAY	N/A	H	M
T1.1.3.6	OBSERVE DISPLAY OF NEW/ CHANGED AIRPORT ENVIRONMENTAL DATA	R	AIRPORT ENVIRONMENTAL DATA	SYSTEM ENVIRONMENTAL AND STATUS DATA DISPLAY	N/A	H	M
T1.1.3.7	RECEIVE NOTICE OF NEW/CHANGED SYSTEM ENVIRONMENTAL AND STATUS DATA	RVC	SYSTEM ENVIRONMENTAL AND STATUS DATA	TEXTUAL ATC MAIL	N/A	H	M
T1.1.3.8	ENTER SYSTEM ENVIRONMENTAL AND STATUS DATA CHANGE MESSAGE	E	N/A	N/A	SYSTEM STATUS DATA CHANGE	L	M
T1.1.3.9	ADVISE OTHERS OF NEW/CHANGED SYSTEM ENVIRONMENTAL AND STATUS DATA	EVC	N/A	N/A	TEXTUAL ATC MAIL	M	M

Data Objects

Figure 3.4-1. Task Information Requirements Illustration

f. *Criticality:* Tasks are assessed relatively against all other tasks of the position as having EXTREME (E), HIGH (H), MEDIUM (M), or LOW (L) criticality. Imminence of an effect on safety is not a consideration in assessing criticality. The assessment is made using the following definition of criticality:

> *Criticality: The likelihood that failure to perform a task promptly and accurately will affect safe operations.*

3.4.2 Cognitive/Sensory Attributes

This section provides a characterization of tasks in terms of key human attributes involved in the performance of tasks of EXTREME or HIGH criticality. The attribute analysis examines the requirements for human abilities most necessary to perform a task.

Human attributes are related to individual tasks of a job, describing primary influences on controller work behavior that characterize controller task performance. Attributes represent ability requirements, particularly for the complex sensory and cognitive aspects of information-processing tasks. They point out the extensive controller involvement in the processing of system information for controllers at computerized workstations.

The key human processes involved in the performance of controller tasks can be characterized generally as being of the cognitive, sensory, or motor attribute domains. These general domain categories represent one high-level description of the human processes occurring in the man-machine interface (MMI) of command and control systems such as Air Traffic Control. A cognitive attribute reflects a mental process of reasoning, judging, or evaluating a situation or state of affairs. A sensory attribute primarily involves any of the perceptual functions of seeing and hearing, though the functions of touch, smell, and taste also fall into this category. A motor attribute pertains to biomechanical actions, as in depressing a switch, reaching for something, or speaking.

It is useful to apply human process categories at a somewhat more specific level of descriptor than is indicated by these three top-level attributes. A great many attributes (or work-oriented behaviors, sometimes called "abilities") are available at this next level of human process description. For the present purposes only those attributes most meaningful in characterizing the information-processing tasks of air traffic controllers are considered. These positions involve interacting with computerized data and radar displays and controls, and thus the defined attributes of this section should be applicable to many similarly involved jobs. Motor attributes (e.g., arm extension, flexion), though relevant to operator performance, can only be assessed with respect to an established system design. Since the Operations Concepts of this present series of analyses concern workstation requirements of the FAA's Advanced Automation System independent of any design concept, the assessment of motor attributes is not addressed.

Cognitive and sensory attributes are associated with specific controller tasks to characterize the significant human efforts involved. Only tasks of EXTREME or HIGH criticality are assessed at this time. The analysis is not weighted by the likely frequency of task performance. The purposes of this attribute analysis are to:

- Describe primary influences on controller behavior that reflect changes in abilities needed as system automation increases.

- Contribute to an understanding of criteria for successful performance of critical tasks.

- Infer needs for system interaction techniques to aid the controller.

The attribute descriptors of controller work efforts also may serve additional purposes, having potential value in later efforts to:

- Validate the component human performance characteristics to be included in an MMI test bed.

- Validate the human performance content included in controller training programs.

Fourteen cognitive and sensory attributes are relevant to the operational tasks inherent in such computer and radar workstation jobs as are found in air traffic control. Definitions and ATC examples of these attributes are provided in Table 3.4-1. These 14 attributes are grouped by type of task:

Associated With ENTRY (E) Tasks:

Coding

Associated With RECEIPT (R) Tasks:

Movement Detection
Spatial Scanning
Filtering
Image/Pattern Recognition
Decoding

Associated With ANALYTICAL (A) Tasks:

Visualization
Short-Term Memory
Long-Term Memory
Deductive Reasoning
Inductive Reasoning
Mathematical/Probabilistic Reasoning
Prioritizing

Associated With VERBAL COMMUNICATION (VC) Tasks:

Verbal Filtering.

Some controller tasks may be more mechanical in nature, such that any significant attributes involve motor responses (e.g., the task of "Select data sorting technique for automatic presentation of data"). In other instances a task may not significantly require any of the attributes. In these

Table 3.4-1. Cognitive/Sensory Attributes Definitions

CODING	Transformation or translation of information for entry into the system; Converting textual information to graphics or symbols. *Example:* Entering a PIREP; Composing a flight plan amendment.
DECODING	Transformation or translation of information received. *Example:* Recognizing a symbol for a handoff; Reading a Flight Data Entry.
DEDUCTIVE REASONING	Ability to reach a conclusion that follows logically from the known facts or data; Selection from among alternative answers or methods. *Example:* Concluding that two aircraft are on intersecting paths.
FILTERING	Selection of inputs on which to focus attention in the presence of distracting stimuli or high workload; Selective attention; Overload accommodation. *Example:* Identifying communication transmissions for attention during a period of heavy radio traffic.
IMAGE/ PATTERN RECOGNITION	Perception of spatial patterns and relations among static or dynamic visual inputs. May involve orienting oneself to the position or configuration. *Example:* Forming a picture of the traffic situation by reviewing Flight Data Entries on the Flight Data Display.
INDUCTIVE REASONING	Generation of an explanation for a set of specific data or instances, giving structure and meaning to the information; Generalization of working hypotheses from specific events: Discerning basic differences and relationships among symbols, figures, and figure patterns; Generating a new solution to a problem; Ability to make a knowledgeable judgment using incomplete data. *Example:* Checking the adequacy of a proposed aircraft maneuver.

Table 3.4-1. Cognitive/Sensory Attributes Definitions (continued)

LONG-TERM MEMORY	Mental storage of knowledge over a period of time and selective recall of items relevant to a situation. *Example:* Remembering aircraft characteristics; Remembering procedural instructions or letters of agreement relevant to an uncommon situation, such as an airshow or large flight formation.
MATHEMATICAL/ PROBABILISTIC REASONING	Translation of uncertainty into probability; Assigning a subjective probability regarding the likelihood of an event occurring; Ability to use probabilities to identify optimal courses of action. *Example:* Assessing the risk of an aircraft maneuver.
MOVEMENT DETECTION	Recognition of the physical movement of a visual object; Estimation of its direction or speed. *Example:* Observing aircraft on the Situation Display responding to a clearance or advisory.
PRIORITIZING	Ordering of events in sequence; Establishing priorities. *Example:* Deferring a request for flight plan changes in the presence of more urgent activity.
SHORT-TERM MEMORY	Mental storage and selective recall of relevant information over a brief period of time. *Example:* Briefly retaining and entering an aircraft callsign.
SPATIAL SCANNING	Rapid identification or detection of objects or events displayed in a wide or complicated visual field. *Example:* Observing the Situation Display for new aircraft; Searching for data in a table.
VERBAL FILTERING	Same as FILTERING, but limited to voice communications.
VISUALIZATION	Observation of spatial patterns and subsequent mental transformations into other spatial patterns. *Example:* Determining the effect of a proposed aircraft maneuver on other aircraft; Comparing intended time-position profiles for intersection in position/altitude/time.

cases, no attributes appear in the attribute table. See Figure 3.4-2 for a sample layout of the Cognitive/Sensory Attributes table.

For Entry Tasks

For Receipt Tasks

For Analytical Tasks

For Voice Communication Tasks (Receipt Only)

		E	R					A							VC
TASK NUMBER	TASK STATEMENT	Coding	Movement Detection	Spatial Scanning	Filtering	Image/Pattern Recognition	Decoding	Visualization	Short-Term Memory	Long-Term Memory	Deductive Reasoning	Inductive Reasoning	Mathematical/ Probabilistic Reasoning	Prioritizing	Verbal Filtering
T1.2.1.1	RECEIVE NOTICE OF POTENTIAL AIRCRAFT/ VEHICLE CONFLICT AT THIS POSITION						D								F
T1.2.1.2	DETECT CONFLICT ALERT INDICATION				F		D								
T1.2.1.3	OBSERVE POTENTIAL AIRCRAFT/VEHICLE CONFLICT SITUATION		M	S	F	I		V				I	M		
T1.2.1.4	DETERMINE VALIDITY OF AIRCRAFT/VEHICLE CONFLICT NOTICE OR INDICATION										D		M		
T1.2.1.5	DETERMINE APPROPRIATE ACTION TO RESOLVE AIRCRAFT/VEHICLE CONFLICT SITUATION								S			I		P	
T1.2.1.6	ADVISE CONTROLLER OF POTENTIAL/ACTUAL AIRCRAFT/VEHICLE CONFLICT	C													
T1.2.1.7	ISSUE ADVISORY IN REGARD TO AIRCRAFT CONFLICT														
T1.2.1.9	REVIEW CONFLICT RESOLUTION ADVISORY						D	V				I		P	
T1.2.2.1	RECEIVE CONTROLLER NOTICE OF POTENTIAL LOW ALTITUDE SITUATION AT THIS POSITION						D								F
T1.2.2.2	DETECT MSAW INDICATION				F		D								

Figure 3.4-2. Cognitive/Sensory Attributes Illustration

3.4.3 Performance Requirements

The tasks of EXTREME or HIGH criticality identified in the Task Information Requirements (Section 3.4.1) require expeditious and accurate performance for effective operational control. Important task performance requirements are identified in this section, and reported in the Critical Task Performance Criteria in Appendix D of the relevant data volumes.

Different performance criteria apply to different task types. The following are the performance criteria that can apply to each task type:

Associated With ENTRY (E) Tasks:

Accuracy of Entry
Implementation Time

Associated With RECEIPT (R) Tasks:

Accuracy of Receipt
Recognition Time

Associated With ANALYTICAL (A) Tasks:

Planning Time
Accuracy of Time Estimates
Accuracy of Spatial Estimates
Accuracy of Probability Estimates
Appropriateness of Action
Appropriateness of Timing

Associated With VERBAL COMMUNICATION (VC) Tasks:

Implementation Time
Accuracy of Communication.

Definitions of these task performance criteria are contained in Table 3.4-2.

This analysis identifies those performance criteria deemed most important for each of the tasks with EXTREME or HIGH criticality, as identified in the Task Information Requirements table (Section 3.4.1). For each task in the Performance Criteria table (data volumes Appendix D) indication is provided for one or more performance criteria that are important to effective task accomplishment, if any. See Figure 3.4-3 for a sample Performance Criteria table.

Table 3.4-2. Performance Criteria Definitions

ACCURACY OF COMMUNICATION	Measures the accuracy of a controller's verbal communication using air-to-ground or ground-to-ground communications. *Example:* The controller gives the correct runway number for an arrival aircraft.
ACCURACY OF ENTRY	Measures the syntactical accuracy of inputs to the work-station console. *Example:* The controller uses the correct function key to implement a desired function.
ACCURACY OF PROBABILITY ESTIMATES	Measures the accuracy of an estimate of the probability that an event will occur. *Example:* Estimate of the likelihood that a pilot will request a reroute around bad weather.
ACCURACY OF RECEIPT	Measures the accuracy of the controller's receipt of displayed information. *Example:* The controller reads the altitude of an aircraft correctly from the Full Data Block.
ACCURACY OF SPATIAL ESTIMATES	Measures the accuracy of estimated positions, directions, and distances. *Example:* Accuracy of estimates of lateral or longitudinal separation between aircraft.
ACCURACY OF TIME ESTIMATES	Measures the accuracy of estimated times or intervals. *Example:* Accuracy of an estimated time interval required for an aircraft to complete a manuever.
APPROPRIATENESS OF ACTION	Measures the effectiveness of a chosen action in the particular situation. *Example:* The chosen action is successful in resolving a conflict situation and does not cause a new conflict unnecessarily.
APPROPRIATENESS OF TIMING	Measures whether an action that was otherwise correct failed to achieve the desired result because it was not implemented at the proper time. *Example:* Delivering a clearance to vector around restricted airspace in sufficient time to allow the aircraft to perform the maneuver.

Table 3.4-2. Performance Criteria Definitions (continued)	
IMPLEMENTATION TIME	Measures the time required to implement a selected action once planning has been completed. Example: Interval from the selection of a resolution of a conflict to verification that the pilot is effectively carrying out the required manuevers.
PLANNING TIME	Measures the time required to determine a response to a recognized condition. The planning process may involve: - Remembering a pre-planned action - Identifying a desirable condition - Identifying alternative actions to achieve a desirable condition - Evaluating the cost of an action in time and effort - Evaluating the possible side effects of an action - Comparing actions and selecting one to implement. Example: Interval from the recognition of a conflict to the decision on how it is to be resolved.
RECOGNITION TIME	Measures the interval from the first manifestation of a specific condition until it is recognized and understood sufficiently to permit planning a response. Example: Interval from the first development of an aircraft conflict to recognition that the conflict exists.

For Entry Tasks | For Receipt Tasks | For Analytical Tasks | For Voice Communication Tasks

TASK NUMBER	TASK STATEMENT	E		R		A						VC	
		Accuracy of Entry	Implementation Time	Accuracy of Receipt	Recognition Time	Planning Time	Accuracy of Time Estimates	Accuracy of Spatial Estimates	Accuracy of Probability Estimates	Appropriateness of Action	Appropriateness of Timing	Implementation Time (Verbal Communication)	Accuracy of Communication
T1.1.2.3	SEARCH AIRSPACE/MOVEMENT AREAS TO ASSESS AIRCRAFT SEPARATION				R			S	P				
T1.1.2.4	PROJECT MENTALLY AN AIRCRAFT'S FUTURE POSITION/ALTITUDE/PATH					P	T	S					
T1.1.2.10	DETERMINE WHETHER AIRCRAFT WILL BE SEPARATED BY LESS THAN PRESCRIBED MINIMA					P	T	S	P				
T1.1.3.1	DETECT EQUIPMENT STATUS ALERT				R								
T1.1.3.3	DETECT AERONAUTICAL AND METEOROLOGICAL ALERT				R								
T1.1.3.10	DETECT AIRPORT ENVIRONMENTAL DATA ALERT				R								
T1.1.4.15	RESTORE AUTOMATIC HANDOFF FOR TRACK(S)	A											
T1.1.4.17	ENABLE AUTOMATIC POINTOUT	A											
T1.2.1.1	RECEIVE NOTICE OF POTENTIAL AIRCRAFT/ VEHICLE CONFLICT AT THIS POSITION			A									A

Figure 3.4-3. Performance Criteria Illustration

3.4.4 *Deleted*

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3.5 DECOMPOSITION OF TASKS TO ELEMENTS

Task Elements are the final level of the Operations Concept analysis (see Figure 3.5-1) and are derived from information contained in the Composition Graphs, Task Statements, and Task Information Requirements. Task Elements are the procedural steps and actions by which a task is accomplished.

Each Task Element Sub-table consists of a Sub-table Header and Task Element Structure (see Table 3.5-2).

3.5.1 Task Element Structure

Each statement of an element is a sentence composed of a verb, object, and optional object modifiers. Objects encompass user input messages and displayed output (see Figure 3.5-2). The syntax of an element is as follows:

VERB [MODIFIER] OBJECT [MODIFIER] *descriptive phrase*,

example: SCAN emphasized Flight_Data_Entry *for altitude information*,

where SCAN is the verb and Flight_Data_Entry is the object. Appendix C in the data volumes contains the data object titles to be used in stating those elements involving system input and output messages and functions. Reduction of Task Element statements from the Task Statement, task data, and UIL input/output objects is illustrated in Figure 3.5-2.

The tables of Task Elements presented within Appendix E of the data volumes are actually composites of sub-tables, each sub-table being devoted to the decomposition of a single operational task. Each Task Element contains four columns of element information:

Column 1 -	Element Number
Column 2 -	Task Element Statement
Column 3 -	Name of the Object(s) Acted Upon
Column 4 -	Number of Objects, representing the number of objects a controller typically would be acting upon in performance of the element.

The **Element Number** is an expansion of the associated Task Number to reflect a visual and logical grouping of elements within a task, but no formal or rigid sequencing requirements are to be inferred. Logical relations are indicated between the elements with notations of *O*, *A*, or *A/O*. These notations correspond to the logical branching constructs of *OR*, *AND*, and *AND/OR*. In a straightforward series of three elements for a hypothetical Task A1.4.8.1, the element numbers appear as:

A1.4.8.1.1
A1.4.8.1.2
A1.4.8.1.3

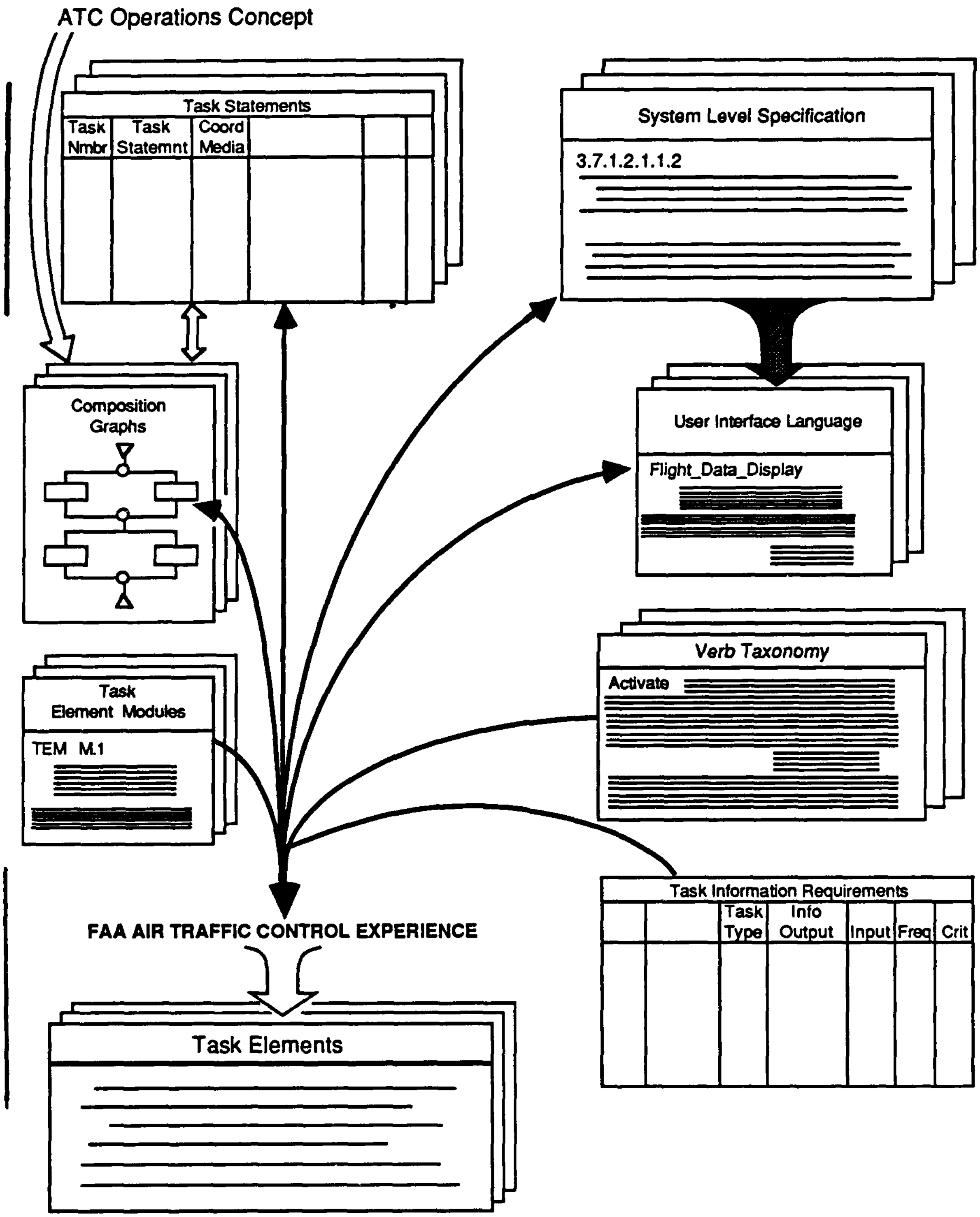

Figure 3.5-1. Task Element Analysis

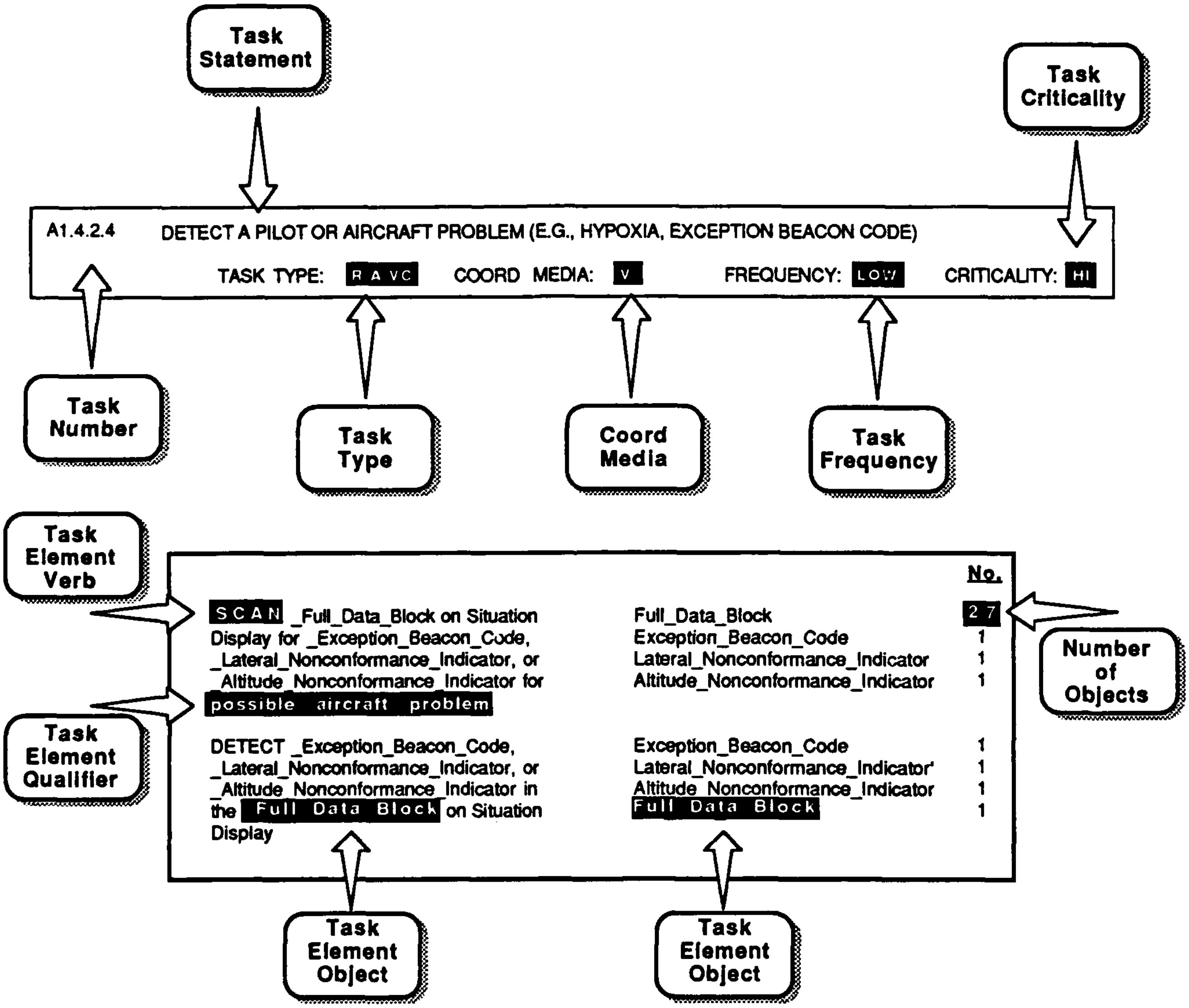

Figure 3.5-2. Sample Task Element Sub-table

Task Element Statement verbs are capitalized, and only one verb can be included for an element. More than one object may be included that is applicable to that verb in that element sequence. Objects involving system input and output data objects are specified at the lowest appropriate level as listed in data volume Appendix C. Thus, in some cases the object "Full Data Block" may be cited. In other instances, particular entries in a Full Data Block may warrant citation in the element statement. Particular UIL data objects (data volume Appendix C) directly used in the particular Task Element are emphasized by underscores preceding and between words of the object name (e.g.,_Situation_Display). Objects not cited in the UIL or not specifically used in the particular element statement but referred to for clarity are not accompanied by underscores (e.g., _Conflict_Indicator on the Alert and Resolution Display). Other element objects, such as "mental traffic picture," information obtained by direct observation of displays outside the workstation, and matters determined by mediatory (cognitive) element actions, also are not underlined between words.

Narrative comments added for clarity following the Task Element Statement are bracketed with asterisks (* *). A single asterisk in front of the element verb signifies that the element is an optional step, not necessarily performed in all situations, such as the option to input a parameter rather than accept a system default, or the option to display certain information not automatically displayed.

The **Object(s)** is a summation of the specific UIL data objects cited in the element statement as being directly acted upon in that particular Task Element (i.e., those objects set off by underlining between words).

The **Number of Objects** projects how many instances or representations of a data object a controller would deal with in performing the individual Task Element in that task. Again, a generalized facility and time scenario is assumed. The numbers represent normal situations rather than worst-case scenarios or system limits. Data volume Appendix D presents the quantities of data objects assumed in certain specific situations frequently encountered in the Task Elements. These numbers are estimates based on controller experience, rather than on rigorous quantitative analysis.

A list of some rules governing the creation of Task Elements is contained in Table 3.5-1. Derivation of the Task Elements is the final phase of the Operations Concept analysis. Thus, by following a process of identifying system events, rigorously decomposing to the task responses to those events, and continuously validating interim products via close user-group review, designers and planners are provided with a logical, accurate, and complete description of the user-oriented capabilities required by the Advanced Automation System.

3.5.1a Sub-table Header

The Sub-table Header contains an identifying Task Number, Task Statement, Task Type, Coordination Media, Task Frequency, and Task Criticality. Discussion of this information is contained in Subsections 3.2.7 and 3.4.1. This information is added to the Task Element Sub-tables in lieu of the previous Enhanced Task Statements derived from the former Dialogue Description of Subsection 3.4.4.

3.5.2 Element Verb Taxonomy

An important aspect of Task Element analysis is the list of verbs describing elemental activity at computerized workstations. This list of verbs is called the Task Element verb taxonomy. Figure 3.5-3 portrays a hierarchy of three levels of allowable element verbs. The lowest level of verb in the hierarchy is used in stating elements, unless use of that level becomes system design specific.

Table 3.5-1. Some Rules for Task Element Generation
1. An asterisk (*) preceding a Task Element action verb indicates that the particular element may not always be performed, but be an optional step or limited to certain situations.
2. Objects are stated in their singular form. The last column of the element tables provides the indication of object multiplicity.
3. Element statements are to be clearly descriptive of the action. For instance, it is insufficient to state "SCAN_Situation_Display." The statement should describe what is being scanned for in that action.
4. When a UIL input data object title indicates two opposite actions (e.g., Select/ Inhibit, Emphasize/ Deemphasize), the one action is stated that is relevant to the task at that point in the sequence.
5. When a UIL input data object title does not specifically indicate the input action (e.g., Track), clarify the specific action in the modifier noted between asterisks (i.e., in the instance of the Track function: *Coast,* *Start,* *Drop,* *Hold,* *Flight Plan Extrapolation,* *Crosstell,* or *Suspend*)
6. Not more than two hierarchical levels of display output data objects should be called out in the "Objects" column of the element tables.

USER-INTERNAL TAXONOMY		
PERCEIVE	ACQUIRE	DETECT SEARCH SCAN EXTRACT CROSS-REFERENCE
	IDENTIFY	DISCRIMINATE RECOGNIZE
MEDIATE	ANALYZE	CATEGORIZE CALCULATE ITEMIZE TABULATE
	SYNTHESIZE	ESTIMATE INTERPOLATE TRANSLATE INTEGRATE FORMULATE PROJECT/ EXTRAPOLATE
	ASSESS	COMPARE EVALUATE
	DECIDE	
COMMUNICATE	TRANSMIT	CALL ACKNOWLEDGE RESPOND SUGGEST DIRECT INFORM INSTRUCT REQUEST
	RECEIVE	

USER-INPUT TAXONOMY		
CREATE	ASSOCIATE	NAME GROUP
	INTRODUCE	INSERT
	ASSEMBLE	AGGREGATE OVERLAY
	REPLICATE	COPY INSTANCE
INDICATE	INITIATE	
	REFERENCE	
ELIMINATE	REMOVE	CUT DELETE
	STOP	SUSPEND TERMINATE
	DISASSOCIATE	RENAME UNGROUP
	DISASSEMBLE	SEGREGATE FILTER
	SUPPRESS	
	SET-ASIDE	
MANIPULATE	TRANSFORM (CHANGE ATTRIBUTE)	
ACTIVATE	PERFORM (___TEM)	
	EXECUTE (___FUNCTION)	

Figure 3.5-3. Verb Taxonomy for Task Elements

Because precision and consistency are crucial to the traceability and completeness of the overall Operations Concept, each term is defined explicitly in Appendix C in a manner that is intended to be design-independent. The Task Element verbs and their definitions are from a taxonomy developed by Lenorovitz, et al. [26] in an extension of work reported by Berliner, et al. [1]. Some of the element action verbs are also used as task action verbs (Appendix C), but this does not impair their use in each instance.

3.5.3 Task Element Modules

Task Element Modules (TEMs) are essentially "macros," groups of elements called out by a single identifier. For example, "PERFORM TCS, Receiving TCS G/G Communications" is the title of one TEM. It represents a set of several action elements. The TEM statement is used as an "element" as a shorthand way to reference the complete set of elements each time they occur in a task. TEMs are particularly useful to express communication elements by differing media, such as via ATC Mail (electronic transmission of free-form text) versus voice communications (such as via the Voice Switching and Control System in ACFs and the Tower Communications System in ATCTs). TEMs for ATC Mail are defined in Appendix F. The titles of Task Element Modules for VSCS and TPC communications, as well as GI Message, are cited in the same appendix. They are not defined because their operational requirements are not included as part of the AAS SLS. These TEMs are employed as appropriate in subsequent data volumes for stating sets of Task Elements. Defined TEMs are used as an "element" statement by including their TEM identification number, as in "PERFORM TEM M.1, Receiving ATC Mail," with M.1 standing for the first of the defined ATC Mail TEMs. Undefined TEMs do not receive numbering identification.

3.6 USER REVIEW AND VALIDATION

It is possible to develop an Operations Concept that is fully consistent with the SLS and yet is incomplete or impractical from an operational viewpoint. A valid Operations Concept must accurately relate each feature of the SLS functionality to the operational situation(s) in which it is used. Additional documentation such as FAA training materials provides insight into how system functions are used operationally, but it is still essential to obtain extensive input from knowledgeable and experienced users of the system. User input is obtained both from site visits and from user review teams.

3.6.1 Site Visits

Site visits are generally performed early in the data-gathering phase, before much if any analysis is performed. The objective of the site visit is to observe and interview operational personnel active in the position(s) of interest. Supervisors are interviewed as well, because they are knowledgeable concerning the position of interest and can usually devote more time to the interview process.

The sites to be visited are selected with care. There is considerable variation from one facility to another in traffic characteristics and levels, airspace, weather and geographic features, local procedures, and even the operational positions employed; this variation is more marked among airport Towers but may also be observed at en route Centers. Because the variation from facility to facility is so great, concentrating site visit activity on an atypical facility could bias or even invalidate the analysis results. Therefore, the sites to be visited are selected to provide a representative cross-section of all significant variables.

The site visits are performed according to a methodical plan to ensure consistency of results. Where possible, "strawman" analysis data and/or other structured interview forms are used as interview vehicles. Appendix G of each data volume records what sites have been visited. Appendix E includes samples of the site visit materials used. New site visit materials are provided in Appendix J of the pertinent data volume.

3.6.2 User Review Team

As the analysis progresses, formal review and validation by a duly constituted user group ensures accuracy, completeness, and operational validity of the results. One function of the Sector Suite Requirements Validation Team (SSRVT) is to provide review and validation of AAS Operations Concept documents. The SSRVT is composed of experienced controllers, selected not only for their personal expertise and extensive experience but to provide a representative cross section of the controller force in terms of:

- Facility type
- Facility size
- Geography
- Operational position.

As of July 1988, the SSRVT includes controllers currently active in Centers, Towers, and TRACONs, as well as FAA Headquarters. Operational positions represented include "line" controllers from Centers and Towers, and supervisors through the facility chief level. SSRVT members are assigned on a continuing basis rather than ad hoc. As a result, the membership is thoroughly conversant with the objectives, history, and progress of the AAS program. Accordingly, the SSRVT maintains a firm sense of direction, focusing on long-term program goals. Emphasis on long-term membership also promotes consistency and continuity of review/validation results and minimizes any "learning curve" problems.

The SSRVT reviews and validates the various analysis products as they are developed in draft form. Results of SSRVT activity are then reflected in the appropriate data volume Operations Concept.

3.7 TASK - REQUIREMENT TRACEABILITY

Traceability represents a mapping between two entities. From this mapping, traceability matrices can be generated, as shown in Figure 3.7-1. The entities in this case are the tasks found in the FAA Operations Concept and the requirements found in the System Level Specification. A requirement is a physical, functional, or performance requirement in the System Level Specification that must be supported by the AAS design. Ideally, each operational task of a position is fully supported by appropriate system functionality prescribed in the SLS, and each SLS requirement (in the applicable sections of the SLS) responds to a valid position task. Therefore, traceability between tasks and requirements is essential to ensure tasks and system functionality agree. It should be noted that some tasks (Analytic and Verbal Coordination in particular) will not trace because they are beyond the scope of the AAS SLS. Conversely, some

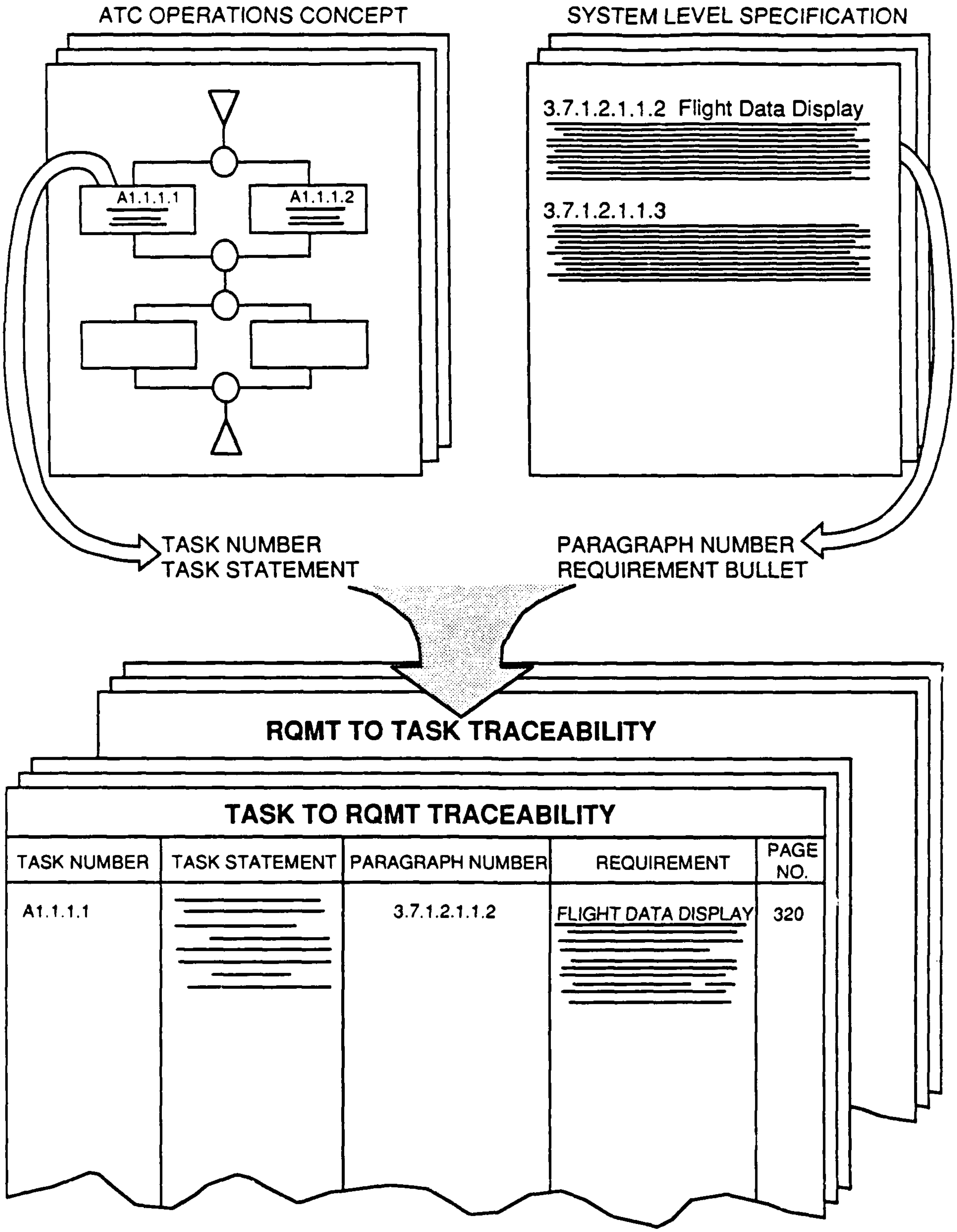

Figure 3.7-1. Traceability

SLS requirements (tracking algorithms, etc.) will not directly map to controller tasks. Appendix F of the data volumes includes matrices tracing each task to the supporting SLS requirements and vice versa. "Orphans" (untraced tasks or requirements) are also included. These matrices are developed through a point-by-point analysis of the SLS and Task List.

It should be noted that the presence of traceability does not by itself guarantee adequate functionality to support the task. The traceability matrices show the presence or absence of specification consistency. Traceability of tasks to requirements allows a mapping of "what" will be provided to "why" SLS functions will be used.

The traceability analysis is part of an interactive process of the FAA Operations Concept creation that is designed to create the best mapping of tasks to requirements. Tasks and requirements are constantly changing via Document Change Requests and better understanding of the SLS. The traceability matrices presented herein are periodically updated to maintain consistency with the AAS engineering baseline.

SECTION 4

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APPENDIX A

ATC OPERATIONAL EVENTS

Air traffic control "events" may be characterized as products of the interactions among aircraft, weather, airspace, airway/airport facilities, surveillance capabilities, and ATC operations. That is, an event is a distinct occurrence (actual or predicted) of which the controller, supervisor, or coordinator becomes aware of or anticipates, and responds to in some manner.

"Airspaces" are bounded by features such as the geography, terrain, obstacles, airway route structures, and weather.

"Aircraft" are functionally related to airspace in that aircraft navigate through airspace using random routes or the formal airway route structures.

The term "airway/airport facilities" is used here to denote local government ground-side facilities (airports, runways) and FAA air-side facilities (ATC equipment, navigation aids). These facilities are directly related to "aircraft" and "airspace" in the sense that aircraft flying published routes rely on navigational aids which may be affected by terrain or man-made obstacles and weather.

"Surveillance capabilities" concern radar coverage of aircraft and weather.

The following two pages provide quick-reference lists of the events applicable to both ACF/ARTCC/TRACON and ATCT operations, with events grouped by categories of event types. The first six categories (Clearance, Flight Status, Conflict, Transfer Control, Aircraft Anomalies, Military and Other Special Operations) pertain to aircraft events. Two categories of events (Traffic Flow Management, System Failure/Degradation) pertain to Air Traffic Control events. Two final categories of events (Position Management, Weather) pertain to ACF/ARTCC/TRACON and ATCT facilities events.

The ACF and ATCT applicable events are followed by listings of events unique to ACF and ATCT operational environments. Operational positions responding to each event are noted in the right-hand columns, with the positions abbreviated as:

CT = Controller (en route, terminal - ISSS/ TAAS/ Host/ ACCC)
OMC = Oceanic Manual Controller
AS = Area Supervisor
AM = Area Manager-In-Charge

TW = ATCT Tower Controller
TS = ATCT Tower Area Supervisor

The definitions of each event appear after these event listings.

EVENTS APPLICABLE TO ACF/ ARTCC/ TRACON AND ATCT OPERATIONS

	Operational Position					
	CT	OMC	AS	AM	TW	TS
CLEARANCE						
1. Clearance Delivery	CT	OMC			TW	
2. Clearance Request	CT	OMC	AS		TW	
3. VFR TCA/ TRSA/ ARSA	CT		AS	AM	TW	
FLIGHT STATUS						
4. Entering/ Leaving Airborne Hold	CT	OMC	AS		TW	TS
5. Filed Flight Plan	CT	OMC			TW	
6. Flight Following Request	CT				TW	
7. Flight Plan Deviation	CT	OMC	AS	AM	TW	TS
8. Initial Contact	CT	OMC			TW	
9. Overdue Aircraft	CT	OMC	AS	AM	TW	TS
9a. Departure Time Receipt	CT	OMC			TW	
CONFLICT						
10. Aircraft Conflict	CT	OMC	AS	AM	TW	TS
11. Airspace Intrusion By Non-Controlled Object	CT				TW	TS
12. Impending Airspace Conflict	CT	OMC	AS		TW	TS
13. Minimum Safe Altitude Conflict	CT		AS	AM	TW	TS
14. Special Use Airspace	CT	OMC	AS	AM	TW	TS
TRANSFER CONTROL						
15. Airspace Release	CT	OMC	AS		TW	TS
16. Facility Closure	CT	OMC	AS	AM	TW	TS
17. Facility Reopening	CT				TW	TS
18. Handoff Receipt	CT	OMC			TW	
19. Pointout Receipt	CT	OMC			TW	
AIRCRAFT ANOMALIES						
20. Aircraft Accident			AS	AM	TW	TS
21. Aircraft Emergency - Airborne	CT	OMC	AS	AM	TW	TS
22. No Radio	CT	OMC	AS	AM	TW	TS
MILITARY AND OTHER SPECIAL OPERATIONS						
23. Airshow	CT		AS		TW	TS
24. Balloon, Glider	CT	OMC	AS	AM	TW	TS

MILITARY AND OTHER SPECIAL OPERATIONS (continued)

25.	Bomb Threat	CT	OMC	AS	AM	TW	TS
26.	Experimental Flight	CT	OMC	AS	AM	TW	TS
27.	Fuel Dumping, Jettison	CT	OMC	AS	AM	TW	TS
28.	Hazardous Cargo	CT	OMC	AS	AM	TW	TS
29.	Hijack	CT	OMC	AS	AM	TW	TS
30.	Law Enforcement	CT	OMC	AS	AM	TW	TS
31.	Lifeguard Mission	CT	OMC	AS	AM	TW	TS
32.	Medical Emergency	CT	OMC	AS	AM	TW	TS
33.	SAFI Flight Check	CT		AS	AM	TW	TS
34.	Special Interest Flight	CT	OMC	AS	AM	TW	TS
35.	Suspect Aircraft			AS			TS

TRAFFIC FLOW MANAGEMENT

36.	Change Flow Pattern	CT	OMC	AS	AM	TW	TS
37.	Flow Management	CT	OMC	AS	AM	TW	TS
38.	Runway Configuration Change	CT	OMC	AS		TW	TS
39.	Sequencing Required	CT	OMC	AS		TW	

SYSTEM FAILURE/DEGRADATION

40.	ACCC (ISSS, TAAS, Host) Failure	CT	OMC	AS	AM	TW	TS
41.	Communication Failure	CT	OMC	AS	AM	TW	TS
42.	Duplicate Beacon Code (ISSS/ TAAS only)	CT				TW	
43.	Equipment Maintenance Need			AS	AM		TS
44.	Flight Data Processing Failure (ISSS/ TAAS only)	CT				TW	
45.	NAVAID Failure	CT	OMC	AS		TW	TS
46.	Radar Surveillance Sensor Failure	CT		AS	AM	TW	TS
47.	Transient Communication Failure	CT	OMC	AS	AM	TW	TS
48.	Transient Computer Failure	CT	OMC		AM	TW	TS

POSITION MANAGEMENT

49.	Controller Overload	CT	OMC	AS	AM	TW	TS
50.	Position Relief	CT	OMC	AS	AM	TW	TS

WEATHER

51.	Ceiling Height Report	CT				TW	TS
52.	PIREP	CT	OMC	AS	AM	TW	TS
53.	Pressure Display/ Report	CT				TW	TS
54.	Severe Weather	CT	OMC	AS	AM	TW	TS
55.	SIGMET/ AIRMET	CT	OMC	AS	AM	TW	TS
56.	Visibility Report	CT	OMC			TW	TS
57.	Wind Shear Report	CT				TW	TS

EVENTS UNIQUE TO ACF/ ARTCC/ TRACON OPERATIONS

	Operational Position					
	CT	OMC	AS	AM	TW	TS
CLEARANCE						
58. Amended Altitude/ Route/ Destination	CT	OMC				
FLIGHT STATUS						
59. ADIZ Pentration		OMC				
60. Aircraft Not Responsive to ATC Direction		OMC				
61. Arrival Message Receipt	CT					
62. En Route Time Receipt	CT	OMC				
CONFLICT						
63. ALTRV/ Airspace Reservation	CT	OMC	AS	AM		
64. Caution Alert	CT	OMC				
65. Flight Plan Conflict	CT	OMC				
66. Flow Conflict				AM		
67. Traffic Congestion				AM		
TRANSFER CONTROL						
68. Aircraft to Edge of Sector	CT	OMC				
MILITARY AND OTHER SPECIAL OPERATIONS						
69. Above FL 600	CT	OMC	AS	AM		
70. Interceptor Flight	CT	OMC	AS	AM		
71. Major Civil Event			AS	AM		
72. Military Training Route	CT	OMC	AS	AM		
73. Refueling, Exercise	CT		AS			
SYSTEM FAILURE/ DEGRADATION						
74. Flight Plan Data Base Failure	CT	OMC	AS	AM		
75. Sector Suite (Workstation) Failure	CT	OMC	AS	AM		
POSITION MANAGEMENT						
76. Automation Status Report		OMC		AM		

EVENTS UNIQUE TO ATCT OPERATIONS

	Operational Position					
	CT	OMC	AS	AM	TW	TS
FLIGHT STATUS						
77. Aircraft Enters ATA					TW	
78. Aircraft/ Vehicle Crossing Active Runway					TW	TS
79. Entering/ Leaving Inbound Ground Hold					TW	TS
80. Entering/ Leaving Outbound Ground Hold					TW	TS
81. Local Traffic					TW	TS
82. Missed Approach/ Go Around/ Practice Approach					TW	
83. Pilot Request for Lighting Manipulation					TW	TS
CONFLICT						
84. Aircraft-Vehicle Conflict						TS
85. Vehicle-Vehicle Conflict						TS
TRANSFER CONTROL						
86. Aircraft to Edge of ATA/ Control Zone					TW	
87. Aircraft/ Vehicle Entering/ Leaving Area of Position Responsibility					TW	
88. Movement Area Release					TW	TS
AIRCRAFT ANOMALIES						
89. Aircraft Emergency/ Incident - Ground					TW	
MILITARY AND OTHER SPECIAL OPERATIONS						
90. Helicopter Operation					TW	
91. Military Operaton					TW	TS
92. Runway/ Taxiway Incursion by Obstacle/ Vehicle/ Aircraft					TW	TS
TRAFFIC FLOW MANAGEMENT						
93. Noise Abatement Procedure						TS
94. Runway/ Taxiway Open/ Close					TW	TS

SYSTEM FAILURE/ DEGRADATION

95.	Airport Equipment Failure	TW	TS
96.	TCCC Failure	TW	TS
97.	TPC Failure	TW	TS

POSITION MANAGEMENT

98.	Alert Inhibited		TS
99.	Position Consolidation/ Deconsolidation	TW	TS

WEATHER

100.	Visibility Observation	TW	TS
101.	Wind Shear Observation	TW	TS
102.	Wind Speed/ Direction Report/ Observation	TW	TS

EVENT DEFINITIONS

ABOVE FL 600: The military may operate aircraft above the Positive Control Area (PCA). These operations above Flight Level 600 (60,000 feet pressure altitude) only involve certain aircraft, and require classified (security) procedures.

ACCC (ISSS, TAAS, HOST) FAILURE: Although redundant units are built into the system, it may be possible to experience a complete loss of the computer system or of some critical component. In this event, it may be necessary for an adjacent facility to assume some control jurisdiction, or for TCCCs to function in Stand-Alone Mode. A TCCC also will function in Stand-Alone Mode if the interface between the ACCC/ ISSS/ TAAS and the TCCC is lost.

ADIZ PENETRATION: Aircraft enter the Air Defense Identification Zone (ADIZ) on approaching the continental United States. ADIZ penetrations are reported to appropriate military agencies.

AIRCRAFT ACCIDENT: It is necessary to analyze the situations leading up to each incident to determine the involvement of Air Traffic Control and to implement remedial action. An accident or incident must be analyzed promptly by supervisory personnel, in addition to in-depth analysis performed off-line.

AIRCRAFT-AIRCRAFT CONFLICT: This is the most critical event in air traffic control. The controller may detect the potential conflict or may receive a system-generated message alert that two aircraft are in conflict.

AIRCRAFT EMERGENCY - AIRBORNE: A pilot will report an aircraft emergency under conditions of inflight fire, rapid decompression, critical system failure, or other problem that the pilot or controller deems an emergency.

AIRCRAFT EMERGENCY/ACCIDENT/INCIDENT - GROUND: An aircraft may be involved in an accident during takeoff, landing, or taxiing. Fires or other incidents may also occur on the ground. (See also Aircraft Accident.)

AIRCRAFT ENTERS ATA: Aircraft operating within an Airport Traffic Area (ATA) must be authorized by ATC. Authorization is normally provided for the purpose of landing at, or taking off from, an airport within the ATA.

AIRCRAFT NOT RESPONSIVE TO ATC DIRECTION: Some aircraft, such as military flights of other nations, may not conform to ATC rules in international airspace. Oceanic traffic must be protected from conflict with these aircraft.

AIRCRAFT TO EDGE OF ATA/CONTROL ZONE: A handoff may be initiated when an aircraft approaches a controller's airspace boundary. The controller position-to-position handoff is accomplished first and then the aircraft is assigned a frequency change to the gaining controller. Handoff to controllers without automation is accomplished by use of interphone.

AIRCRAFT TO EDGE OF SECTOR: A handoff may be initiated when an aircraft approaches a controller's airspace boundary. The controller position-to-position handoff is accomplished first, and then the pilot is assigned a frequency change to the gaining controller.

AIRCRAFT-VEHICLE CONFLICT: This is similar to the Aircraft-Aircraft Conflict except that it involves an aircraft on the ground and a ground vehicle (or, rarely, another aircraft on the ground). The conflict may be observed directly or on the ASDE Display, and does not include a system-generated message.

AIRCRAFT/VEHICLE CROSSING ACTIVE RUNWAY: No aircraft may take off from nor may any aircraft/vehicle cross an active runway without the expressed approval of the Local Controller. Each movement must be coordinated separately.

AIRCRAFT/VEHICLE ENTERING/LEAVING AREA OF POSITION RESPONSIBILITY: An aircraft/vehicle may enter or leave an area of a tower controller's responsibility, such as an aircraft about to enter a movement area from a ramp or an aircraft leaving the movement area to a gate.

AIRPORT EQUIPMENT FAILURE: The failure of airport equipment may affect the operation of aircraft, e.g., the loss of airport lighting at night.

AIRSHOW: (See Refueling/Exercise/Airshow.)

AIRSPACE INTRUSION BY NON-CONTROLLED OBJECT: When an object is within radar coverage, it may be displayed on the Situation Display. Non-controlled aircraft may be displayed in the form of Limited Data Blocks, while tracked aircraft may be displayed in the form of Full Data Blocks. Other objects or phenomena may be displayed in the form of special symbols, contours, graphs, lines, or controller annotations.

AIRSPACE/MOVEMENT AREA RELEASE: A section of airspace belonging to one sector/position may be released to an adjacent sector/position for temporary use. The conditions associated with the release, such as duration, will be identified. Similarly, a section of movement area belonging to one tower position may be released to an adjacent position for temporary use.

AIRSPACE RELEASE: (See Airspace/Movement Area Release.)

ALERT INHIBITED: The inhibiting of system-generated Conflict Alert/Minimum Safe Altitude Warning.

ALTRV/AIRSPACE RESERVATION: Military missions may require the advance reservation of altitudes needed for the mission. Altitude reservations are filed and forwarded to appropriate facilities.

AMENDED ALTITUDE/ROUTE/DESTINATION: An amended altitude and/or route may be requested for any reason. It generally is used to obtain more direct routing, or to avoid weather/turbulence, or for fuel economy. The new route may be airway, NAVAID-direct-NAVAID, RNAV, radar vectors, or coordinates (latitude-longitude) to coordinates. Amended routes also may arise from a change in destination due to pilot request or contingencies.

ARRIVAL MESSAGE RECEIPT: A message received by a Flight Service Station, Airport Traffic Control Tower, and/or an appoach controller of the arrival time (down time) of an aircraft at the destination of intended landing.

AUTOMATION STATUS REPORT: In case of a major failure of the automated equipment of an ACF, the Area Manager must keep abreast of the equipment status and ensure other affected personnel are aware as well, to implement appropriate contingency measures and to cancel them when the equipment is restored.

BALLOON, GLIDER: Balloons (both manned and unmanned) and gliders represent non-controlled objects of which the controller must maintain awareness.

BOMB THREAT: An aircraft that is under the duress of a bomb threat will convey this information to ATC.

CAUTION ALERT: Advisories and safety alerts will be issued when, in the controller's judgment: a potential hazard will exist; an aircraft may encounter phenomena such as parachutists, migratory birds, or gliders; or the aircraft is deviating from its cleared course.

CEILING HEIGHT REPORT: A report is taken either by National Weather Service personnel or by certified tower personnel to determine the height of the ceiling. This is reported to ACF controllers. The ceiling and visibility reports determine whether VFR or IFR conditions exist.

CHANGE FLOW PATTERN: Occasionally an unexpected incident or weather phenomenon will occur which will disrupt the normal traffic flow. The controller will initialize a new traffic flow when this occurs.

CLEARANCE DELIVERY: Clearance delivery is the transmittal of an initial clearance, based upon a filed flight plan, to the pilot by ATC. It signifies the acceptance of the flight plan and includes any modifications interjected by ATC. Non-flight plan items included in the clearance delivery are the assigned beacon code, frequency assignments, and any restrictions. Tower positions deliver IFR clearances in accordance with the ACF letter of agreement or request the long-range clearances from the ACF. VFR clearances may be issued by the tower without coordination with the ACF. At uncontrolled airports or when a tower is closed, a Flight Service Station may do the clearance delivery. When this is impractical or when a VFR departure is made, the controlling ACF sector may deliver the clearance directly. For airfiled flight plans, the Flight Service Station or ACF controller may deliver the clearance. The ACF controller does the delivery for pop-up clearance requests.

CLEARANCE REQUEST: A change of route or altitude may be requested by a pilot for better efficiency due to favorable winds, to avoid turbulence or other weather, or to optimize a climb or descent. This includes requesting the modification of a restriction when it interferes with the pilot/crew judgment. Certain military and special operations may request a block altitude assignment, which assigns airspace with upper and lower boundaries.

COMMUNICATION FAILURE: A failure in intercom, interphone, or air-to-ground frequency transmission/reception of the Voice Switching and Control System (in ACFs) or of the Tower Communications System (in ATCTs) isolates the controller from resources, other facilities, and/or traffic being controlled. Isolated or total failures are possible.

CONTROLLER OVERLOAD: On occasion the traffic activity or complexity will reach a point where the controller will become overloaded either with events or with inputs. The Area Supervisor in ACFs may assign another controller to act as a coordinator or handoff controller, or provide for position resectorization. Similarly, the Tower Area Supervisor in ATCTs may assign another controller to act as a coordinator or assistant controller, or provide for position reassignment or relief. The controller also may directly request assistance from the supervisor.

DEPARTURE TIME RECEIPT: The time an aircraft becomes airborne. When used in conjunction with a computer system, it represents the activation of a proposed flight plan. It differs from an en route time message in that climb characteristics normally are processed when a departure time is entered into the system.

DUPLICATE BEACON CODE: Occasionally a transient aircraft will be handed off to a facility with a beacon code duplicating one already assigned in the facility. The National Beacon Code Allocation Plan is designed to allocate beacon codes to airspace to minimize the occurrence. This event should be effectively eliminated in the full AAS.

EN ROUTE TIME RECEIPT: A pilot may report actual time en route over a specified fix, instead of (or in addition to) reporting departure time. The time is that when an aircraft is entering the controlling facility's environment, such as a VFR requesting IFR services or an oceanic flight entering the system from another FIR. Normally, no climb trajectory is calculated since the aircraft is close to the requested altitude, distinguishing this message from a departure message.

ENTERING/LEAVING AIRBORNE HOLD: The pilot of an IFR aircraft is required to report time and altitude entering a hold or reaching a clearance limit. Another report is required leaving the holding fix or point. The holding pattern may be based on timed legs or some leg length. The pattern may be published or not, and may use right turns (standard) or left turns. VFR aircraft may be held at selected, prominent geographical fixes that can easily be recognized from the air.

ENTERING/LEAVING INBOUND GROUND HOLD: Inbound aircraft may be held on the ground due to other ground traffic, crossing active runways, or the non-availability of gates. Aircraft may be held on taxiways or specially designated areas (penalty boxes), or at the gate.

ENTERING/LEAVING OUTBOUND GROUND HOLD: Outbound aircraft may be held on the ground because of en route delays or restrictions, other ground traffic, or crossing active runways. Aircraft may be held on taxiways or specially designated areas (penalty boxes).

EQUIPMENT MAINTENANCE NEED: NAVAIDs and sensors require periodic preventive maintenance. Since data from these facilities are important inputs to the system, the effect of a requested outage for maintenance must be assessed thoroughly before it is approved or denied.

EXPERIMENTAL FLIGHT: The pilot of an experimental aircraft is required to notify ATC of operation when operating into or out of airports with operative control towers.

FACILITY CLOSURE: Small and medium towers may be closed when there is little or no traffic activity, such as on a midnight shift, or due to weather conditions. Airspace which had been delegated to the tower reverts to the ACF/ ARTCC until the tower is reopened. The control of any aircraft in the area will be coordinated between the facilities during the transition period.

FACILITY REOPENING: Towers which will have been scheduled to be shut down during periods of little traffic activity are reopened during normal scheduled hours. The control of any aircraft in the area will be coordinated between the facilities during the transition period.

FILED FLIGHT PLAN: Pilots requiring ATC services will file a flight plan. Flight plan data are used by the computer system to develop and distribute Flight Data Entries (or Flight Progress Strips). Subsequent changes to the flight plan may be made by flight plan amendments.

FLIGHT DATA PROCESSING FAILURE: Flight data processing performs the flight plan manipulations, planning and tracking in the Host Computer System. Loss of this capability requires the use of manual flight data processing of flight strips. This event will be replaced by the event Flight Plan Data Base failure in the full AAS.

FLIGHT FOLLOWING REQUEST: The pilot of a VFR aircraft may request and be granted/denied Flight Following Service from an ATC facility on a workload-permitting basis. The facility must have radar to provide flight following.

FLIGHT PLAN CONFLICT: The computer program, upon receipt of a new flight plan, flight plan amendment or upon request, will initiate a conflict probe matching this flight against other flight plans. The results will be displayed to the controller.

FLIGHT PLAN DATA BASE FAILURE: Equipment or software malfunction could result in the loss of the flight plan data base. In this unlikely event, all functions are lost except for limited tracking capability.

FLIGHT PLAN DEVIATION: If the current flight plan is in the system, the controller is alerted to: (a) route deviations by track symbology; (b) altitude deviations by altitude conformance indicators; and (c) speed deviations by observing the ground speed. Pilots are required to report significant changes in the true airspeed. A controller may become aware of a deviation not detectable by the system (e.g., if the aircraft does not respond as expected to vectoring directions in a terminal area) by comparing observed and expected aircraft position and movement. Tower controllers also may visually observe either an approach or departure deviation by the aircraft. Tower controllers also may observe a deviation by a ground vehicle from its approved course through the movement area.

FLOW CONFLICT: Flow control measures may conflict with requirements of individual sectors. These conflicts must be resolved to promote orderly traffic flow.

FLOW MANAGEMENT: Flow control is used to establish in-trail spacing of aircraft along a specified route leading into/out of a specific terminal area or geographic region (e.g., ACF). Other forms of flow constraint are Traffic Management Advisories provided by Traffic Management personnel, as well as air and ground holds and EDCTs.

FUEL DUMPING, JETTISON: Pilots may desire to dump fuel or cargo under emergency or other appropriate circumstances.

HANDOFF RECEIPT: As an aircraft progresses through the system it will be handed off from one sector to the next sector or facility. The receiving controller will acknowledge all handoffs either by voice or through the entry of computer messages.

HAZARDOUS CARGO: Military and civilian aircraft may carry dangerous or explosive materials. Special patterns and routings may be flown to avoid populated areas.

HELICOPTER OPERATION: Helicopter operations may differ from other operations and may include hover and air taxi (remaining 100 feet AGL). Taxi is used primarily for helicopters with wheels.

HIJACK: An aircraft that is under the duress of a hijacker or other terrorist action will attempt to convey this information to ATC.

IMPENDING AIRSPACE CONFLICT: An aircraft that may fly into the airspace of special use airspace will trigger an airspace intrusion event.

INITIAL CONTACT: After the transfer of control from one sector/position/facility to another, the pilot will initiate a call on the assigned air-to-ground frequency. The controller will acknowledge the transmission and, if appropriate, advise the pilot that the aircraft is in radar contact and verify the reported altitude.

INTERCEPTOR FLIGHT: The military may desire to intercept aircraft for intruding into sensitive prohibited areas, Air Defense Identification Zones (ADIZs), or other sensitive airspace.

LAW ENFORCEMENT: Law enforcement agencies (Drug Enforcement Administration, Federal Bureau of Investigation, or other federal, state, or local agency) sometimes require ATC cooperation for surveillance and interception of aircraft.

LIFEGUARD MISSION: Military and civilian flights involving medical evacuation and support are termed "Lifeguard" by ATC. These flights are handled as expeditously as possible. Military flights involving medical evacuation also may be known as "Air Evacuation" or "Air Evac."

LOCAL TRAFFIC: Aircraft flying in the immediate vicinity of the airport.

MAJOR CIVIL EVENT: Occasionally, civil events generate extremely large volumes of traffic in a local area. These events normally are well publicized in advance. It is necessary to prepare for such events so that the additional traffic can be accommodated. For instance, flow control measures and extra staffing may be invoked.

MEDICAL EMERGENCY: An aircraft may be in distress with a medical emergency. The pilot may declare an emergency for reasons of passenger problems, incapacitation, disorientation, or other factors affecting crew members' abilities to perform their duties.

MILITARY OPERATION: Military operations may require special handling by the controller. This is especially true of airports with a joint military/civil operation.

MILITARY TRAINING ROUTE: Military Training Routes (MTRs) are designated routes for training in navigation and weapons delivery. Both VFR and IFR routes exist and are published in DOD Flight Information Publications (FLIPs). The routes encompass many altitudes and involve high performance flight profiles.

MINIMUM SAFE ALTITUDE CONFLICT: An aircraft flying below the minimum IFR altitudeis in danger of colliding with terrain or an obstacle if the buffer altitude provided is infringed upon. A system alarm or controller noticing the violation triggers the event.

MISSED APPROACH/GO AROUND/PRACTICE APPROACH: An aircraft on approach to the runway will be controlled as an arrival. If the decision is made not to land the aircraft, it subsequently will be controlled as a departure or resequenced in the arrival pattern.

MOVEMENT AREA RELEASE: (See Airspace/Movement Area Release.)

NAVAID FAILURE: A failure in a navigation aid may impact landing minima at an airport or may require the rerouting of other aircraft.

NOISE ABATEMENT PROCEDURE: A procedure affecting runway/route/altitude usage to reduce aircraft noise levels in the vicinity of an airport during certain times of day.

NO RADIO: Special problems arise when an aircraft has communication problems. It is possible to have only a transmitter or receiver failure on the aircraft, permitting the pilot/crew to hear or to talk. The pilot/crew should squawk Beacon Code 7600 if they know a complete communications failure is at hand. In the tower environment, an aircraft may rock its wings in the air, move ailerons or rudders on the ground, or flash navigation or landing lights as acknowledgement to light signals from the tower.

OVERDUE AIRCRAFT: An aircraft that is more than thirty minutes overdue at a reporting point or destination is considered overdue. Airport traffic may be delayed due to an overdue aircraft.

PILOT REQUEST FOR LIGHTING MANIPULATION: Operation of approach and runway lights may be controlled by the control tower. Pilots may request that lights be turned on/off. Some lights may have intensity control varied as requested.

PIREP: PIREPs are pilot reports of actual weather or atmospheric conditions. A PIREP may deal with winds aloft, turbulence, icing, thunderstorms, cloud cover, or other weather encounters valuable to the controller and other traffic in the area of influence.

POINTOUT RECEIPT: When one controller wants to use a small section of airspace that belongs to another controller, the originating controller may pointout the aircraft to the adjacent controller. The receiving controller will acknowledge the pointout and determine if transfer of control is required. Pointout is a radar term and may include the use of ASDE in towers.

POSITION CONSOLIDATION/DECONSOLIDATION: Tower positions may be consolidated/deconsolidated for lunch relief, training, or because of traffic activity.

POSITION RELIEF: Before assuming control responsibility at a position/sector, the controller will receive a detailed briefing, based on the position checklist, on the traffic situation and all special items affecting the position/sector. When a tower is shut down, the tower controllers are relieved by controllers in the ACF.

PRESSURE DISPLAY/REPORT: The altimeter report, based upon barometric pressure, is continuously taken and displayed. This report is relayed to the pilots to insure they have the correct altimeter setting.

RADAR SURVEILLANCE SENSOR FAILURE: On occasion a radar system will fail. In this event the software will attempt to provide mosaic radar data from other radar sites. If radar coverage is not available, nonradar separation is applied to aircraft in that area.

REFUELING, EXERCISE, AIRSHOW: Refueling is performed by military units for training and operationally to extend the range of aircraft on certain missions. The refueling takes place on a published refueling track in airspace so reserved for that purpose by the military.

Exercises are performed periodically by USAF Strategic Air Command (SAC) and Tactical Air Command (TAC) units. The exercises are part of readiness training and may involve large numbers of aircraft of varying intentions and performance, as well as user activation of special use airspace.

An airshow may involve large numbers of aircraft of varying intentions and performance.

RUNWAY CONFIGURATION CHANGE: Noise abatement procedures, runway maintenance, and weather conditions (primarily wind velocity and direction) determine runway utilization. Runway changes are accomplished to accommodate changes in the airport environment as necessary.

RUNWAY/TAXIWAY INCURSION BY OBSTACLE/VEHICLE/ AIRCRAFT: An obstacle (e.g., deer), vehicle (e.g., cement truck), or an aircraft (e.g., student pilot) may make an incursion at any time on a runway/taxiway. The tower controller must react to these incursions.

RUNWAY/TAXIWAY OPEN/CLOSE: The opening/closing of all or part of the runway/taxiway will affect an airport's operation.

SAFI FLIGHT CHECK: Semi-Automatic Flight Inspection (SAFI) aircraft require special handling so as not to delay their flight or change the programmed route to verify operation of NAVAIDs and sensors.

SECTOR SUITE (WORKSTATION) FAILURE: The failure of one console at a Sector Suite will require the reconfiguration of the consoles. The failure may require the controller to move to a vacant suite or share a suite with another sector. Failure of a current workstation with Plan View Display, Computer Readout Device, and Flight Strip Bays is comparable to Sector Suite failure.

SEQUENCING REQUIRED: The controller/computer will calculate tentative sequences for any defined metering or flow restriction. The aircraft's schedule, predicted delay, delay absorption plan, and trajectory may be revised.

SEVERE WEATHER: During periods of severe weather, turbulence, or icing, an aircraft may be predicted to encounter this phenomenon. The pilot may request, or the controller may initiate, a routing that will bypass the weather.

SIGMET/AIRMET: Significant Meteorological Information (SIGMET) or Airman's Meteorological Information (AIRMET) concern weather significant to aircraft. AIRMET is generally less severe than SIGMET, and is more pertinent to light aircraft because of lack of equipment, instrumentation, or pilot qualification.

SPECIAL INTEREST FLIGHT: Controllers are made aware of special interest flights by the aircraft's callsign (e.g., Air Force One), by remarks on the flight plan, or through their supervisor.

SPECIAL USE AIRSPACE: Controlled aircraft will be routed so as to avoid restricted, warning, or Military Operations Areas (MOAs) that are in use.

SUSPECT AIRCRAFT: Involves a procedure used by the FAA in coordination with other governmental agencies.

TCCC FAILURE: Although redundant units are built into the system, it may be possible to experience a complete or partial loss of the computer system. In this event, it may be necessary for an adjacent facility to assume some control jurisdiction.

TPC FAILURE: The failure of one Tower Position Console (TPC) in a tower will require reconfiguration of the consoles. The failure may require the tower controller to move to a vacant TPC or share a workstation with another position.

TRAFFIC CONGESTION: Because of a peak in arrival or departure scheduling, reduced capacity at an airport or sector (due, for instance, to severe weather or runway maintenance), or heavy use of a particular route, traffic may become congested. New routings must be provided to prevent/relieve traffic congestion.

TRANSIENT COMMUNICATION FAILURE: If communications with an aircraft are unreliable, the controller will determine whether it is the aircraft or ACF's/ACTC's communications that are at fault. The controller may switch air-to-ground frequencies or use an alternate communication path. If ground-to-ground communications are unreliable, the controller may activate an alternate communications path through the use of VSCS/TCS controls.

TRANSIENT COMPUTER FAILURE: Occasionally a controller may experience a system malfunction, such as an IFR aircraft entering the airspace without a data block.

VFR TCA/TRSA/ARSA: A pilot/crew may request clearance into, out of, or through a Terminal Control Area (TCA), or elect to participate in the Stage II (sequencing) or Stage III (sequencing and separation) program.

VEHICLE-VEHICLE CONFLICT: This is similar to Aircraft-Vehicle Conflict except that it involves multiple ground vehicles. The conflict is observed directly or on the ASDE Display, and does not include a system-generated message.

VISIBILITY REPORT/OBSERVATION: An observation is taken either by National Weather Service personnel or by certified tower personnel to determine airport visibility. This is reported to ACF controllers. The ceiling and visibility reports determine whether VFR or IFR conditions exist.

WIND SHEAR REPORT/OBSERVATION: Instruments to measure wind shear have been installed near the runways at major airports. Data from these sensors are displayed in the tower for use by tower controllers and are relayed to pilots. They may be reported to ACF controllers.

WIND SPEED/DIRECTION REPORT/OBSERVATION: A report is taken either by National Weather Service personnel or by tower personnel to determine wind direction/velocity. Wind instruments may be located at the center of the field and at the end of the runways. Observation may be made directly of windsocks and other local indications of wind speed and direction.

APPENDIX B

BASELINE OPERATIONAL SCENARIOS

This appendix contains five baseline operational scenarios. Material for each scenario includes background situations, routine activity, and other activity. Construction of the scenarios is described in Section 3.2.6 above. Specific controller tasks and system interaction implied by these scenarios are expanded from these baseline scenarios and reported in Appendix H of the appropriate data volumes.

The scenarios should be viewed independently: activity, weather, etc. in one scenario have no bearing on the other baseline scenarios.

Figure B-1 shows the fictitious airspace structure assumed for these scenarios.

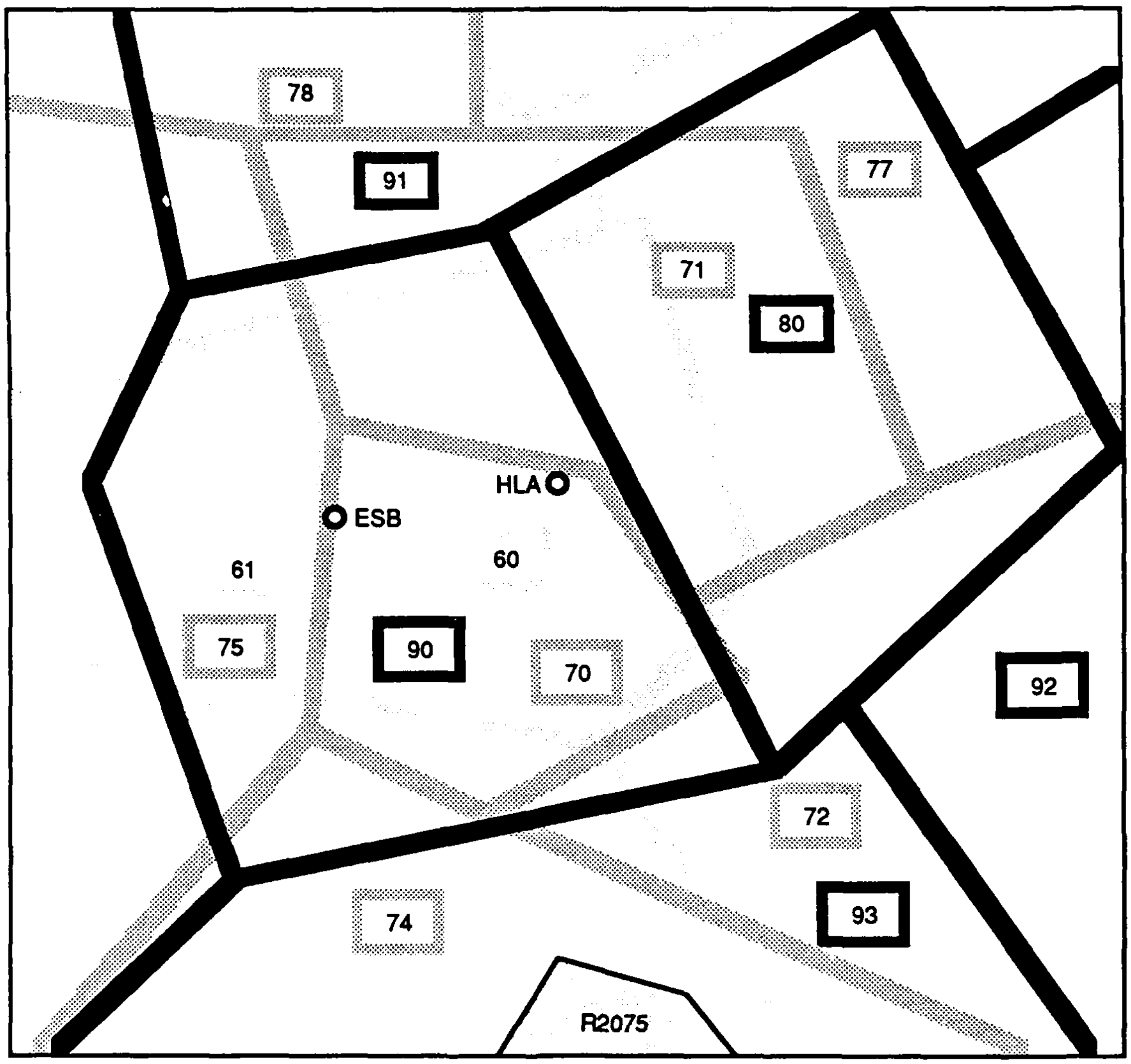

Figure B-1. Operational Scenario Sector Airspace Diagram

SCENARIO I: EN ROUTE HIGH ALTITUDE

a. **BACKGROUND:** This scenario concerns Sector 80, an en route high altitude sector at a fictitious Denver Center. This sector exchanges traffic with four adjacent high-altitude sectors (Sectors 90, 91, 92, and 93) and three low-altitude sectors (Sectors 71, 72, and 77). At scenario start (1700Z), the sector is experiencing a normal level of routine activity as described below. All aircraft are in conformance with their flight plans. No emergencies or significant equipment outages exist, and no special activity is known. A large weather system is developing in the Midwest. There is no significant weather within Denver Center's airspace.

b. **ROUTINE ACTIVITY:** Normal traffic in Sector 80 at this time of day is 20 aircraft under the sector's control. Typically, an aircraft requires 20 minutes to traverse the sector, so that on the average one aircraft will enter this sector and another will leave every minute. Except as otherwise noted, handoffs are initiated automatically and are always accepted. All aircraft are Mode C equipped. At scenario start, 20 aircraft are under Sector 80's control, including two in handoff from Sector 80 to another sector. Two aircraft are in handoff to Sector 80. No aircraft are in pointout status.

   Events applicable to routine activity are Handoff Receipt (for entering aircraft) and Aircraft to Edge of Sector (for departing aircraft). Events applicable to other scenario activity are indicated below.

c. **OTHER ACTIVITY:** The situations that follow occur in addition to the routine activity described above. Situations are annotated with reference numbers to track between this scenario and the expanded scenarios in the data volumes. Note that a situation may enter the scenario more than once.

TIME (Z)

1704 **EVENT:** ***Refueling***

SITUATION: AG204, a flight of two military aircraft, is in Group Suppression status in Sector 80. It is joined by ACME20 for inflight refueling. Controller action is required to prevent generation of false conflict alerts and update the data base as necessary. **I-1**

1705 **EVENT:** ***Impending Airspace Conflict, Clearance Delivery***

SITUATION: Restricted Area R2075 (in Sector 93) becomes "hot." Expected duration is 30 minutes. Following aircraft will violate the restricted area if they continue their currently cleared routes of flight: DAL745 and EAL259. Control action is required to avoid a conflict with the restricted airspace, without creating other conflict. **I-2**

1708 **EVENT:** ***Pointout Receipt***

SITUATION: Sector 72 points out an aircraft (M34581) which will briefly enter Sector 80 while climbing to altitude in Sector 93. Control action is needed to accept the pointout. **I-3**

1709 **EVENT:** ***Flow Management, Sequencing Required, Clearance Delivery***

SITUATION: Flow control (twenty miles in trail) is imposed on traffic bound for St. Louis. Control action is required for en route sequencing of aircraft affected by the flow restriction. **I-4**

1712 **EVENT:** ***Aircraft Emergency - Airborne, Amended Altitude/Route/Destination, Clearance Delivery***

SITUATION: DAL67 declares an inflight emergency and requests immediate descent to 10000 feet and clearance direct to the nearest suitable emergency airport. Control action is required to determine the nearest suitable airport, determine what conflicts (if any) will result from issuing the requested altitude and reroute, resolve any conflicts, issue appropriate clearances, determine the nature of the emergency, make required coordination and notifications, and complete other required actions connected with the emergency. **I-5**

1714 **EVENT:** ***Clearance Request***

SITUATION: Sector 90 requests approval of incorrect altitude for direction of flight for UAL624. **I-6**

1717 **EVENT:** ***Aircraft to Edge of Sector***

SITUATION: DAL67 is handed off to Sector 72. Control action is required to resume normal acceptance of handoffs. **I-5**

1719 **EVENT:** ***PIREP, Amended Altitude/Route/Destination, Clearance Delivery***

SITUATION: UAL105 reports severe turbulence at 39000 feet in Sector 80 at a location near the boundaries of Sectors 92 and 93, and requests Flight Level 350. Control action is needed to perform required coordination, issue a new clearance, pass the urgent PIREP to Sectors 92 and 93, and update the data base. **I-7**

1722 **EVENT:** ***Aircraft to Edge of Sector***

SITUATION: EAL344, about to exit Sector 80, will briefly enter Sector 90 before entering Sector 93. An automatic handoff is initiated to Sector 90 but, because of the brief transition period involved, Sector 90 rejects the handoff and requests a pointout. Control action is required to retract the handoff, issue the pointout to Sector 90, and initiate a handoff to Sector 93. **I-8**

1724 **EVENT:** ***NAVAID Failure, Clearance Delivery***

SITUATION: A NAVAID used in the airway structure of Sectors 77, 80, and 91 fails unexpectedly. Duration of the outage is unknown. The backup is in maintenance with a 30 minute recall. Control action is needed to provide navigational guidance along this portion of the route of flight until the backup can be recalled. **I-9**

1726 **EVENT:** ***Flight Plan Deviation, Clearance Delivery***

SITUATION: N325LJ is out of conformance with assigned altitude. Action is needed to detect the nonconformance and restore flight plan conformance. **I-10**

1730 Scenario ends.

NOTE: Reference numbers following each scenario situation are appended to help the reader track between the baseline scenario in this volume and the expanded scenario in Appendix H of the data volumes. Multiple appearances of a reference number denotes a situation that enters the scenario more than once.

SCENARIO II: TERMINAL DEPARTURE SECTOR

a. **BACKGROUND:** Sector 60 is a departure control sector, most of whose traffic is departures from ESB, a major airport in Denver Center's area with two sets of parallel runways. A small satellite airport (HLA) also generates traffic for Sector 60. Eighty percent of Sector 60's traffic is scheduled air carrier traffic from ESB; 5% is general aviation from ESB; 10% is general aviation departures from HLA; and 5% is overflight traffic. Most ESB traffic traverses Sector 60 en route to Sector 70 or Sector 71, the low-altitude transition sectors which overlie Sector 60. At scenario start (1800Z), the sector is experiencing a normal level of routine activity as described below. All aircraft are in conformance with their filed flight plans. No emergencies or significant equipment outages exist. All aircraft are Mode C equipped. An airshow is scheduled to begin at ESB to 1830Z. Weather is currently good in Denver Center's area, but severe thunderstorms are forecast throughout the Midwest.

b. **ROUTINE ACTIVITY:** Normal activity in Sector 60 at this time of day is 10 departure aircraft under the sector's control. Aircraft depart ESB at one-minute intervals, alternating between Runways 35L and 35R. In addition, one aircraft departs HLA every nine minutes. Departures require an average of nine minutes to exit the sector. At this time, departures normally are handed off directly to Sector 70 or Sector 71. Occasionally a pointout is required before the departing aircraft reaches altitude. These pointouts are not considered routine activity. Overflights occur infrequently and are not considered part of routine activity. Overflights require 20 minutes to traverse the sector.

Events applicable to routine activity are Aircraft to Edge of Sector. Events applicable to other scenario activity are indicated below.

c. **OTHER ACTIVITY:** The situations that follow occur in addition to the routine activity described above. Situations are annotated with reference numbers to track between this scenario and the expanded scenarios in the data volumes. Note that a situation may enter the scenario more than once.

TIME (Z)

1803 **EVENT:** ***Airspace Intrusion by Non-Controlled Object***

SITUATION: A non-controlled object (glider) enters Sector 60's airspace from Sector 70. No Conflict Alert is generated, but control action is needed to separate traffic from the non-controlled object in the terminal control area. **II-1**

1805 **EVENT:** ***Aircraft to Edge of Sector***

SITUATION: AWE110 will briefly traverse Sector 71 after exiting Sector 60 for Sector 70. Handoff to Sector 71 is required. Control action is required to initiate the handoff. Sector 71 requests that Sector 60 redirect the handoff directly to Sector 70. **II-2**

1807 **EVENT:** ***Amended Altitude/Route/Destination, Clearance Delivery***

SITUATION: N699LJ will depart ESB normally in accordance with its special VFR. The pilot wishes to file an amended route of flight. Control action is needed to coordinate the change, update the data base, issue required clearances, and maintain separation. Upon track initiation, an unreasonable altitude is indicated. After questioning the pilot, the aircraft resumes normal flight. **II-3**

1808 **EVENT:** ***Handoff Receipt, Aircraft to Edge of Sector***

SITUATION: N104PG, an overflight, is handed off from Sector 61 to Sector 60. N104PG will traverse Sector 60 and be handed off to Sector 70. Control action is needed to accommodate the overflight. The Mode C altitude report is not in conformance. The controller issues an altimeter setting. The altitude is verified and validated. **II-4**

1810 **EVENT:** ***N/A***

SITUATION: The non-controlled object exits controlled airspace and is no longer a factor. **II-1**

1812 **EVENT:** ***SIGMET/AIRMET***

SITUATION: A SIGMET is received reporting development of severe thunderstorms just north of ESB. Control action is required to acknowledge the SIGMET and broadcast to traffic. **II-5**

1816 **EVENT:** ***Severe Weather, Sequencing Required, Clearance Delivery***

SITUATION: Because of the severe thunderstorms developing north of ESB, traffic departing via Runway 35 must divert. Control action is required to vector departures around the thunderstorm area while maintaining accuracy of the flight plan data base. **II-6**

1818 **EVENT:** ***PIREP, Amended Altitude/Route/Destination, Clearance Delivery***

SITUATION: N645G reports severe turbulence on the departure route north of ESB. Hail may have damaged the aircraft. The pilot requests clearance back to ESB. An amended clearance is coordinated, issued, and the data base is revised. The PIREP is distributed. **II-7**

1821 **EVENT:** ***Runway Configuration Change***

SITUATION: ESB Supervisor reports that departures will be made from Runway 17 instead of Runway 35 because of the thunderstorm activity off the departure end of Runway 35. Control action is required to maintain separation. **II-8**

1823 **EVENT:** ***Airshow***

SITUATION: Several aircraft take off from ESB to participate in the scheduled air show. Control action is required to prevent generation of false conflict alerts or MSAW alarms by these aircraft. **II-9**

1824 **EVENT:** ***Filed Flight Plan, Clearance Delivery***

SITUATION: N294NJ, having departed HLA under VFR, wishes to file an IFR plan. Control action is needed to update the data base, issue required clearances, and maintain separation. **II-10**

1825 **EVENT:** ***Aircraft Emergency - Airborne***

SITUATION: Sector 90 reports an aircraft emergency (M12345). M12345 has requested an immediate landing at ESB. Control action is needed to enable M12345 to land immediately as requested while minimizing disruption to other traffic and maintaining separation. **II-11**

1830 Scenario ends.

NOTE: Reference numbers following each scenario situation are appended to help the reader track between the baseline scenario in this volume and the expanded scenario in Appendix H of the data volumes. Multiple appearances of a reference number denotes a situation that enters the scenario more than once.

SCENARIO III: EN ROUTE LOW ALTITUDE

a. **BACKGROUND:** Sector 70 is a low-altitude transition sector in Denver Center. It is adjacent to Sector 60 (ESB Tower departure sector); to Sectors 71, 72, 74, and 75 (low altitude); and to Sector 90 (en route high altitude). At scenario start (1900Z), Sector 70 is experiencing a normal amount of routine activity as described below. All aircraft are in conformance with their flight plans. No emergencies, significant equipment outages, or special activities exist. During the past two hours a weather system has been building in Sector 90 from 24000 to 30000 feet. There have been several pilot reports of turbulence at altitudes between 24000 and 27000 feet in Sector 90. At scenario start (1900Z), Sectors 70 and 72 are combined.

b. **ROUTINE ACTIVITY:** A normal level of traffic for the combined sectors 70 and 72 at this time of day is 13 aircraft. This traffic includes 10 departures from ESB or HLA, which enter Sector 70 from Sector 60 and exit to Sector 90, and 3 overflights. Departing traffic enters Sector 70 at the rate of one per minute and requires 10 minutes to climb through Sector 70. Overflights (primarily general aviation) enter at the rate of one every 10 minutes and require an average of 30 minutes to traverse the combined Sectors 70 and 72. Unless otherwise noted, handoffs are initiated automatically and are always accepted. At scenario start, 11 controlled aircraft (including one in handoff status to another sector) are in Sector 70's airspace and 2 are in Sector 71's airspace. All aircraft are Mode C equipped. One aircraft is in handoff from Sector 60. No aircraft are in pointout status.

   Events applicable to Routine Activity are Handoff Receipt (for entering aircraft) and Aircraft to Edge of Sector (for departing aircraft). Events applicable to other scenario activity are indicated below.

c. **OTHER ACTIVITY:** The situations that follow occur in addition to the routine activity described above. Situations are annotated with reference numbers to track between this baseline scenario and the expanded scenarios in the data volumes. Note that a situation may enter the scenario more than once.

TIME (Z)

1905 **EVENT:** ***Impending Airspace Conflict, Clearance Delivery***

SITUATION: Restricted Area R2075 (in Sector 74) becomes "hot" up to 14000 feet. Expected duration is 30 minutes. The following aircraft will violate the restricted area if they continue their currently cleared routes of flight: EAL147 and AWE232. Control action is required to avoid a conflict with the restricted airspace, without creating other conflicts. **III-1**

1908 **EVENT:** ***Pointout Receipt***

SITUATION: EAL745, climbing from Sector 74 to Sector 90, is pointed out to Sector 70. Control action is required to accept the pointout. **III-2**

1910 **EVENT:** ***Severe Weather, Flow Management, Clearance Delivery***

SITUATION: Sector 90 controller reports that the weather system in Sector 90 is now so severe that altitudes 24000 through 27000 feet are unusable. ESB and HLA departure traffic must be rerouted to avoid the severe weather in Sector 70. Action is required to reroute aircraft involved, issue appropriate clearances, and update the data base. **III-3**

1914 **EVENT:** ***Controller Overload***

SITUATION: Because of the additional workload caused by the weather system in Sector 90, the workload for combined Sectors 70 and 72 exceeds the capacity of a single control position. The sectors must be decombined. Control action is required to decombine the sectors. **III-4**

1917 **EVENT:** ***Special Interest Flight, Handoff Receipt***

SITUATION: TEAL32, a test flight not on a standard route of flight, is about to enter Sector 70 from Sector 75. Because TEAL32 is a test flight, automatic handoff is inhibited. Control action is required to accept the manually initiated handoff. **III-5**

1921 **EVENT:** ***Aircraft Emergency - Airborne, Aircraft Conflict, Clearance Delivery***

SITUATION: N505LJ reports lost cabin pressure and begins descent to 10000 feet. A Conflict Alert is generated by this deviation involving N505LJ and AG235. Control action is required to resolve the conflict alert, issue new clearances, update the data base, make required notifications, and complete other required actions connected with the emergency. **III-6**

1925 **EVENT:** *Aircraft to Edge of Sector*

SITUATION: TEAL32 is about to enter Sector 75 briefly en route to Sector 74. Control action is required to initiate a pointout to Sector 75 and a handoff to Sector 74. **III-5**

1926 **EVENT:** *Aircraft to Edge of Sector*

SITUATION: Sector 75 does not respond to the pointout of M13579. Control action is required to detect and respond to the lack of action on the pointout. **III-5**

1927 **EVENT:** *Aircraft to Edge of Sector*

SITUATION: Sector 74 accepts the handoff of M13579. **III-5**

1930 Scenario ends.

NOTE: Reference numbers following each scenario situation are appended to help the reader track between the baseline scenario in this volume and the expanded scenario in Appendix H of the data volumes. Multiple appearances of a reference number denotes a situation that enters the scenario more than once.

SCENARIO IV: TOWER LOCAL POSITION

a. **BACKGROUND:** ESB is a large airport in Denver Center's airspace, with two sets of parallel runways oriented 17/35 and 08/26. The runways do not intersect. Maximum capacity of each set of runways is one takeoff or departure per minute (alternating between left and right runways). A small general aviation airport (HLA) is located 20 miles east of ESB. Ninety percent of ESB traffic is scheduled air carrier traffic; nearly all of the remainder is general aviation. All ESB traffic operate in accordance with Terminal Control Area procedures. Overflights through the Airport Traffic Area (ATA) are very rare. At scenario start (2000Z), ESB Tower is experiencing a normal level of routine activity as described below. No flow constraints are in the system. All aircraft are in conformance with their filed flight plans or current clearances. No emergencies or significant equipment outages exist, and no special activity is planned. Weather in the ESB area is currently good, but thunderstorms possibly associated with microburst activity are predicted in the vicinity of ESB over the next several hours. Airport management has advised that Runway 08L/26R will be closed for a period of several days beginning approximately 2000Z today, for resurfacing.

b. **ROUTINE ACTIVITY:** Normal operation at ESB at this time of day is for departures to the north (Runway 35) and arrivals to the west (Runway 26). At this time, aircraft are taking off at a rate of one per minute, alternating between Runways 35L and 35R. Ten aircraft are in the departure sequence. Arrivals normally occur at a rate of one every 90 seconds, alternating between Runways 26L and 26R. Departures are handed off to Sector 60 on eastbound traffic and Sector 61 on westbound traffic. Unless otherwise noted, all handoffs are initiated automatically and are always accepted. Ground movements in the movement area, other than movements of arriving or departing aircraft, are not considered routine activity.

c. **OTHER ACTIVITY:** The situations that follow occur in addition to the routine activity described above. Situations are annotated with reference numbers to track between this scenario and the expanded scenarios in the data volumes. Note that a situation may enter the scenario more than once.

TIME (Z)

2001 **EVENT:** ***Aircraft to Edge of Sector, Pointout Receipt***

SITUATION: N63A, a general aviation helicopter inbound to HLA, is pointed out to ESB by Sector 60. Control action is required to accept the pointout. **IV-1**

2003 **EVENT:** ***Wind Speed/Direction Report/Observation***

SITUATION: Wind at ESB, which has been almost calm, may be shifting to the southwest. Action is needed to confirm that current runway usage is still appropriate under current conditions, and to monitor surface winds. **IV-2**

2006 **EVENT:** ***Runway/Taxiway Open/Close***

SITUATION: Airport management advises that Runway 08L/26R is closed for resurfacing as of 2015. Arrival traffic must use Runway 26L, so only one arrival every two minutes can be accommodated. Control action is needed to modify the arrival sequence and arrival rate, update the data base, and perform required coordination. **IV-3**

2007 **EVENT:** ***Flow Management***

SITUATION: Flow management for New York is implemented. UAL86 anticipates departure for New York (JFK) at 2014, receives an EDCT of 2114. Because a gate hold is not desirable, the aircraft will be held at the penalty box. Control action is needed to revise the departure sequence, perform required coordination, and transfer UAL86 to the Ground Control position. **IV-4**

2012 **EVENT:** ***Wind Shear Report/Observation, PIREP***

SITUATION: AWE250 reports severe wind shear conditions immediately following takeoff from Runway 35R. At the same time, the LLWAS confirms wind shear conditions. Action is required to advise departures of the wind shear until condition dissipates, and to disseminate the PIREP. **IV-5**

2013 **EVENT:** ***Amended Altitude/Route/Destination, Clearance Delivery***

SITUATION: N414LJ, number nine in the departure sequence, wishes to file an amended route of flight. The requested amendment is too complex for Local Control to respond. Local Control requests that Clearance Delivery coordinate and reissue the clearance. Action is needed to transfer the Flight Data Entry back to Clearance Delivery. **IV-6**

2016 **EVENT:** ***Severe Weather***

SITUATION: Heavy thunderstorm activity commences just north of ESB. Coordination with the Departure Controller is required to divert departures around the activity. **IV-7**

2019 **EVENT:** ***Runway/Taxiway Incursion by Obstacle/Vehicle/Aircraft, Missed Approach/Go Around/Practice Approach***

SITUATION: One of the three vehicles involved in the runway resurfacing mistakenly enters Runway 08R/26L. At the same time, NWA806 is approaching touchdown. A go-around is issued to NWA806. The Local Controller coordinates the re-sequencing of NWA806 with the Center controller. **IV-8**

2022 **EVENT:** ***Aircraft Conflict***

SITUATION: Airborne departing aircraft N113LJ, misunderstanding control instructions for diversion around the thunderstorm activity, overtakes and approaches departing aircraft PAA787, causing a Conflict Alert to be generated. Control action is needed to resolve the conflict. **IV-9**

2025 **EVENT:** ***Runway Configuration Change***

SITUATION: Wind is now steadily from the southwest. Because of this and the persistent thunderstorm activity north of ESB, the supervisor determines that north departures are no longer feasible. The Local Controller is advised that action is required to commence departures to the south (Runways 17L/R), to revise the departure sequence accordingly, to update the data base, and to perform required coordination. **IV-10**

2028 Scenario ends.

NOTE: Reference numbers following each scenario situation are appended to help the reader track between the baseline scenario in this volume and the expanded scenario in Appendix H of the data volumes. Multiple appearances of a reference number denotes a situation that enters the scenario more than once.

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SCENARIO V: TERMINAL ARRIVAL SECTOR

a. **BACKGROUND:** Sector 61 is an arrival control sector, most of whose traffic is landing at ESB, a major airport in Denver Center's area with two sets of parallel runways. Eighty percent of Sector 61's traffic is scheduled air carrier traffic landing at ESB; 15% is general aviation; and 5% is overflight traffic. Most ESB traffic comes from Sector 75, the low-altitude sector that overlies Sector 61. At scenario start (2100Z), the sector is experiencing a normal level of routine activity as described below. All aircraft are in conformance with their flight plans. No emergencies or significant equipment outages exist. All aircraft are Mode C equipped. Weather is currently good in Denver Center's area.

b. **ROUTINE ACTIVITY:** Normal activity in Sector 61 at this time of day is nine arrival aircraft under the sector's control. The aircraft arrival rate for VFR parallel runway operation on Runways 26L/26R is one every minute. Arrival aircraft are handed off from Sector 75 at approximately 35 miles from the airport at either the northwest or southwest side arrival gate. The arrival controller provides the spacing required by the final controller in preparation for the turn onto the runway extended center line.

   VFR Terminal Control Area (TCA) aircraft may be sequenced with the IFR traffic. TCA aircraft call Sector 61 directly and are subsequently given a beacon code, identified, and sequenced. Overflights occur infrequently and are not considered part of routine activity. On occasion, overflight traffic may be pointed out to Sector 61.

   Events applicable to routine activity are Handoff Receipt and TCA, TRSA, and ARSA traffic. Events applicable to other scenario activity are indicated below.

c. **OTHER ACTIVITY:** The situations that follow occur in addition to the routine activity described above. Situations are annotated with reference numbers to track between this scenario and the expanded scenarios in the data volumes. Note that a situation may enter the scenario more than once.

TIME (Z)

2103 **EVENT:** ***Minimum Safe Altitude Conflict***

SITUATION: N345GJ, a VFR aircraft on a TCA clearance, has descended below the minimum safe altitude. The full data block associated with this flight is emphasized and displays the MSAW alert. Control action is needed to observe the data block alert, issue an advisory to N345GJ, and follow up with action to observe the aircraft 's altitude conformance. **V-1**

2106 **EVENT:** ***Position Relief***

SITUATION: The supervisor advises the controller that it is time for a break and that another controller will relieve the current controller. The relieving controller must be briefed from the position checklist, must assume the position, and must invoke controller preferences. The traffic workload increases and the controller requests assistance. **V-2**

2111 **EVENT:** ***Law Enforcement***

SITUATION: Local authorities are pursuing a bank robber. Sky Watch 1, a helicopter, is used during the high-speed chase on the local interstate freeway. The helicopter pilot has asked for priority in the local TCA. The controller complies with the request, although no traffic is delayed. **V-3**

2115 **EVENT:** ***Radar Surveillance Sensor Failure***

SITUATION: All targets are in coast mode. There is an apparent problem with the radar system. Controllers must be prepared to perform immediate control action and coordination if radar tracking is not restored. **V-4**

2117 **EVENT:** ***Radar Surveillance Sensor Failure***

SITUATION: The supervisor has changed to the back-up radar channel. Radar tracking is normal. All targets are showing normal tracking. **V-5**

2120 **EVENT:** ***Special Interest Flight***

SITUATION: The president is aboard Air Force 1, which is inbound to ESB. The aircraft has been handed off to Sector 61. **V-6**

2122 **EVENT:** ***Aircraft Emergency - Airborne***

SITUATION: Air Force 1 declares an emergency because of a fire in the number 2 engine. Control action is needed to inform others of the situation. **V-7**

2123 **EVENT:** ***Entering/Leaving Airborne Hold***

SITUATION: All aircraft inbound to ESB are held because of the emergency. **V-8**

2129 **EVENT:** ***Entering/Leaving Airborne Hold***

SITUATION: Normal operations are resumed with the successful landing of AF1. **V-8**

2130 Scenario ends.

NOTE: Reference numbers following each scenario situation are appended to help the reader track between the baseline scenario in this volume and the expanded scenario in Appendix H of the data volumes. Multiple appearances of a reference number denotes a situation that enters the scenario more than once.

SCENARIO VI: TOWER GROUND POSITION

a. **BACKGROUND:** ESB is a large airport in Denver Center's airspace, with two sets of parallel runways oriented 17/35 and 08/26. The runways do not intersect. Maximum capacity of each set of runways is one takeoff or departure per minute (alternating between left and right runways). Ninety percent of ESB traffic is scheduled air carrier traffic; nearly all of the remainder is general aviation. All ESB traffic operate in accordance with Terminal Control Area procedures. Overflights through the Airport Traffic Area (ATA) are very rare. At scenario start (2100Z), ESB Tower is experiencing a normal level of routine activity as described below. No flow constraints are in the system. All aircraft are in conformance with their current clearances. No emergencies or significant equipment outages exist, and no special activity is planned. Weather in the ESB area is currently good, but thunderstorms possibly associated with microburst activity are predicted in the vicinity of ESB over the next several hours. Some segments of the movement area are not visible to the ground controller. This requires movement around the cab to see all the ground traffic.

b. **ROUTINE ACTIVITY:** Normal operation at ESB at this time of day is for departures to the north (Runway 35) and arrivals to the west (Runway 26). At this time, aircraft are taking off at a rate of one per minute, alternating between Runways 35L and 35 R. Ten aircraft are in the departure sequence. Arrivals normally occur at a rate of one per ninety seconds, alternating between Runways 26L and 26R. Local Control position normally transfers arrival traffic to Ground Control position after the aircraft have cleared runway 26R. Ground movements in the movement area, other than movements of arriving or departing aircraft, are not considered routine activity.

c. **OTHER ACTIVITY:** The situations described on the following pages occur in addition to the routine activity described above. Situations are annotated with reference numbers to track between this scenario and the expanded scenarios in the data volumes. Note that a situation may enter the scenario more than once.

TIME (Z)

2102 **EVENT:** ***Entering/Leaving Inbound Ground Hold***

SITUATION: Arrival flight COA1261 is held in the penalty box since the gate to which the aircraft is assigned is occupied. The outbound flight at the gate has mechanical problems. **VI-1**

2104 **EVENT:** ***Entering/Leaving Outbound Ground Hold, Flow Management***

SITUATION: Traffic management procedures are implemented for flights departing for St. Louis. Since gate availability is critical, gate holds are not practical. St. Louis bound aircraft TWA760 is taxied to the penalty box awaiting the estimated departure clearance time of 2125. **VI-2**

2107 **EVENT:** ***Runway Configuration Change***

SITUATION: The supervisor has observed a significant change in the wind speed and direction. The runway configuration will be changed to runway 08 for all aircraft. AAL554 is presently on a taxiway for runway 35. AAL554 must be reversed and taxied to Runway 08. **VI-3**

2110 **EVENT:** ***Aircraft/Vehicle Crossing Active Runway***

SITUATION: A disabled aircraft is being towed from a taxiway, cross active runways, to a hanger. Since the towed aircraft is slow moving, extra time may be required to clear an active runway. The hanger is on the far side of the field. Due to traffic volume the towed aircraft may be delayed in route which means this obstruction will continue for some time. **VI-4**

2113 **EVENT:** ***Pilot Request For Lighting Manipulation***

SITUATION: An alternate taxiway will be used to try to unblock a log jam created by the towed aircraft. Taxiway lights are selected (turn-on) when needed or their use is requested by aircraft on the taxiway. **VI-5**

2116 **EVENT:** ***Runway/Taxiway Incursion by Obstacle/Vehicle/Aircraft***

SITUATION: Ground control position observes EAL333 with cargo door ajar with several large containers on the intersection of the ramp and the taxiway. EAL333 requests to return to the gate. **VI-6**

2118 **EVENT:** ***Aircraft Emergency/Incident - Ground***

SITUATION: NWA535 lands and is taxiing onto the taxiway. Ground Control position observes what appears to be smoke coming from the wheel. Ground Control position advises NWA535 of the smoke which is increasing. NWA535 asks for the fire equipment to stand by as a precautionary measure. **VI-7**

2123 **EVENT:** ***Position Relief***

SITUATION: The towed aircraft is at the hanger; EAL333 has retrieved the containers; and NWA535 is safely at the gate. The supervisor asks the ground controller if he is ready for a break. **VI-8**

2130 Scenario ends.

NOTE: Reference numbers following each scenario situation are appended to help the reader track between the baseline scenario in this volume and the expanded scenario in Appendix H of the data volumes. Multiple appearances of a reference number denotes a situation that enters the scenario more than once.

SCENARIO VII: TOWER CLEARANCE DELIVERY/FLIGHT DATA POSITION

a. **BACKGROUND:** ESB is a large airport in Denver Center's airspace, with two sets of parallel runways oriented 17/35 and 08/26. The runways do not intersect. Maximum capacity of each set of runways is one takeoff or departure per minute (alternating between left and right runways). Ninety percent of ESB traffic is scheduled air carrier traffic; nearly all of the remainder is general aviation. All ESB traffic operate in accordance with Terminal Control Area procedures. Overflights through the Airport Traffic Area (ATA), are very rare. At scenario start (2200Z), ESB Tower is experiencing a normal level of routine activity as described below. No flow constraints are in the system. No emergencies or significant equipment outages exist, and no special activity is planned. Weather in the ESB area is currently good, but thunderstorms possibly associated with microburst activity are predicted in the vicinity of ESB over the next several hours.

b. **ROUTINE ACTIVITY:** Normal operation at ESB at this time of day is for departures to the north (Runway 35) and arrivals to the west (Runway 26). At this time, aircraft are taking off at a rate of one per minute, alternating between Runways 35L and 35 R. Ten aircraft are in the departure sequence. Arrivals normally occur at a rate of one per ninety seconds, alternating between Runways 26L and 26R. Ground movements in the movement area, other than movements of arriving or departing aircraft, are not considered routine activity. Aircraft are requesting long-range departure clearances at the rate of one per minute. All flight plan information has been entered and is routinely available in the form of flight data entries.

c. **OTHER ACTIVITY:** The situations described on the following pages occur in addition to the routine activity described above. Situations are annotated with reference numbers to track between this scenario and the expanded scenarios in the data volumes. Note that a situation may enter the scenario more than once.

TIME (Z)

2205 EVENT: *Clearance Request*

SITUATION: N345JG has requested a new route and destination through the Ground Control position. The flight data entry is transferred back to the Clearance Delivery/Flight Data position to copy the request, enter it into the computer system, and issue the new clearance as appropriate. **VII-1**

2207 EVENT: *Clearance Request*

SITUATION: PAA776 requests clearance but a flight data entry is not displayed on that call sign. The Clearance Delivery position requests a departure FDE on PAA776. **VII-2**

2208 EVENT: *Filed Flight Plan*

SITUATION: An FDE is now available on PAA776. However, preferential route and truncation/tailoring are indicated as well as the requirement for full route clearance. The Clearance Delivery position requests a full route readout on PAA776. **VII-3**

2210 EVENT: *Filed Flight Plan*

SITUATION: PAA776 is an international flight with many unusual identifiers in the route field. The clearance delivery position requests PAA776 identify some of the identifiers. **VII-4**

2212 EVENT: *Severe Weather*

SITUATION: The supervisor has just concluded a discussion with the Traffic Management Coordinator. It has been decided to implement the severe weather avoidance program (SWAP) for all departure proceedings out the north gate. All aircraft currently with clearances, going out the north gate, are transferred back to the Clearance Delivery position. **VII-5**

2214 EVENT: *Entering/Leaving Outbound Ground Hold*

SITUATION: The supervisor informs the Clearance Delivery position that the penalty box area is full. Gate hold procedures are in affect until other areas are available. **VII-6**

2217 EVENT: *Helicopter Operation*

SITUATION: Life Guard 1, a medical helicopter, is required at the scene of a fire and the pilot requests special handling and a special VFR clearance direct to the fire. Clearance Delivery position requests the supervisor coordinate the request with the other tower positions as well as with the ACF. **VII-7**

2219 **EVENT:** ***Military Operation***

SITUATION: The Clearance Delivery notes the FDE of a special operations flight. Several F-4s are observed leaving the National Guard hanger. The Clearance Delivery position alerts the other positions. **VII-8**

2222 **EVENT:** ***Military Operation***

SITUATION: Lima Kilo 01, a flight of 4 F-4s, requests clearance including an afterburner climb on a coded route. The Clearance Delivery position decides to look-up and review the procedures associated with the stereo flight plan. **VII-9**

2230 Scenario ends.

NOTE: Reference numbers following each scenario situation are appended to help the reader track between the baseline scenario in this volume and the expanded scenario in Appendix H of the data volumes. Multiple appearances of a reference number denotes a situation that enters the scenario more than once.

APPENDIX C

VERB GLOSSARY

GLOSSARY OF CONTROLLER TASK ACTION VERBS

This is a glossary of the action verbs used to state air traffic operational tasks for the National Airspace System. They pertain to operational activities only, and do not incorporate actions involved in such peripheral and off-line activities as training, administration, and report preparation.

In stating tasks, a distinction generally is made between "what the person does" and "what gets done." Statements of what the person does are called "worker-oriented" statements, and these are more appropriate for the description of task element procedures. Statements of what gets done are called "job-oriented" statements. For the most part, tasks should be "job-oriented" (or goal-oriented), providing a more functional description of "what" gets done without specifying "how" that action gets done by the individual.

Some statements can imply both a worker and a job orientation. In other instances, the statement of a job-oriented task, through a reader's familiarity with the action, will readily imply a well-defined notion of what the person actually is doing. Interpretation of the specific work action in many instances is dependent upon the sub-activity context in which the task is a component. Tasks state what gets done to a machine or system, and not what a machine or system does.

There are 65 task action verbs listed here as currently available for tasks of air traffic control positions. They represent a composite of those defined previously for ACF sector controllers, ACF oceanic controllers, ATCT controllers, ACF supervisory personnel, and Tower Supervisors. Fifty of these verbs are generally applicable terms, suitable for use with tasks of many jobs involving interaction with computers and communication systems. Fifteen verbs are specific to controller terminology (these are marked with an asterisk).

Associated with each verb are indications of the Task Types that might employ the verb. Task Types are abbreviated as follows:

E = Entry Task (including function messages and ATC Mail)

R = Receipt Task (including display outputs and ATC Mail, as well as direct observation)

A = Analysis Task

VC = Verbal (voice) Communication Task

Tasks accommodating multiple types are noted with a slash (/) between the type abbreviations.

Action Verb	Verb Definition
ACCEPT	Respond to an originating controller or computer message, indicating that the receiving controller assumes complete or partial responsibility for the requested action, as appropriate. (cf. Approve) **E, A/E, A/VC, VC**
ACKNOWLEDGE	Respond to an originating controller or computer message indicating a call or message has been received, without further commitment as to what action will be taken. (cf. Receive) **E, V/C**
ADJUST	Change or fine-tune a data base, controls, display, and/or communication control. **E, E/R/A**
APPROVE	Respond favorably to a request as a person in authority, as in approving a clearance request. (cf. Accept, Deny, Forward, Inform) **E, A/E, A/VC, VC**
ASSIGN	Designate or commit an item such that the computer can act on it, as in assigning a beacon code to an aircraft. Also, modify personnel responsibilities, as in designating a controller to take over a particular control position. **E, VC**
BRIEF	Give concise preparatory information concerning all sector or position activities and the operational situation to another person, as when turning over responsibility for a position. **A/VC**
BROADCAST	Transmit a recording or voice message to a general audience (as opposed to contacting a specific person) via radio. **E, VC**
CHECK	Visually examine a hardware item to establish its operational state or condition. **E/R/A, A**
CHOOSE	Make a mental decision on a course of action or mentally pick one of several alternatives, as in choosing a desired flow sequence. **A**
COMPARE	Relate one item to another to note relative similarities and/or differences, as in comparing a maintenance request to a maintenance schedule. **A**
CONDUCT *	Accomplish a series of related actions to achieve a definite goal, as in conducting a radio/radar search for an aircraft. **E, VC**

CONTACT *	Establish communications via radio or telephone with another person, informing them of or discussing matters of concern, as in contacting a pilot to verify arrival intentions. **VC**
DECLARE *	State with emphasis that a situation exists, as in declaring the existence of an emergency event. **E, E/VC, VC**
DELETE	Remove an information item (as in deleting the highlighting of an item on a display) or cancel a previous action (as in canceling a request for pilot position reports). This includes verbal actions as well as computer information. **E**
DENY	Refuse to grant a request. (cf. Approve, Forward, Inform, Issue, Reject) **E, A/E, A/VC, VC**
DETECT	Discern visually or aurally a newly occurring fact or item (not being watched for, i.e., not the object of preceding attention), usually from a display, such as an alarm indicator or the action of an aircraft target symbol. **R, R/A**
DETERMINE	Process information mentally to reach a decision about a situation, state of affairs, or the timing of an action. **R/A, A**
DIRECT	Issue instructions or a directive to a controller, directing that a certain action be taken. (cf. Forward, Inform, Issue) **E, VC**
DISCUSS	Exchange information/ideas on a particular topic with one or more others, typically not involving a resolution of differences. (cf. Negotiate) **E/R, A/VC, VC**
EMPHASIZE	Provide prominence to an item on a display. **E**
ENTER	Insert data, text, or a system message into the computer system. (Do not use ENTER just to avoid generating a more job-oriented term.) **E, A/E**
EVALUATE	Examine and judge the merits of an action or situation for a definite purpose and to reach a decision. **A**
FLAG *	Physically position a flight progress strip to serve as a reminder of future action needed. This serves as a manual equivalent of the automation action to Emphasize a display item. **E**

FLIGHT-FOLLOW *	Provide advice and information to assist pilots in conduct of a flight not otherwise being controlled, to include tracking that flight on the Situation Display. **R/A/VC**
FORCE *	Compel the display of something, as in forcing a Full Data Block or Flight Data Entry that otherwise would not be presented. (cf. Quick-Look) **E, E/R**
FORMULATE	Mentally compose or prepare the content of a verbal or computer input message or plan, including all required or pertinent elements thereof, such as an advisory or clearance. **A**
FORWARD	Send information verbally or electronically to another position. (cf. Direct, Inform, Issue) **E, VC**
INFORM	Impart information to another person. (cf. Direct, Forward, Issue) **E, VC**
INHIBIT	Prevent the occurrence of a machine function, as in inhibiting an alert function. (cf. Suppress) **E**
INITIATE	Begin an action or sequence, as in initiating a handoff or starting a track. **E, VC**
ISSUE *	Distribute or communicate information as guidance to a pilot or vehicle operator by radio, as in issuing clearances, alerts, and advisories. (cf. Direct, Forward, Inform) **E, VC**
NEGOTIATE	Confer in order to come to a mutually acceptable agreement, as when negotiating with a pilot the technique to be used for accomplishing a flight delay. (cf. Discuss) **A/VC, VC**
OBSERVE	Take notice visually or watch attentively something or somewhere for an expected message, object, event, or occurrence of something. (A here-and-now observation, as opposed to "Perceive," an evolving sensory process.) (cf. Detect, Perceive) **R, R/A**
OBTAIN	Acquire possession of an item, such as a flight progress strip, from another location, such as the flight strip printer. **R**
OFFSET *	Relocate the position of a Data Block in adapted increments in relation to its associated target on the display. **E**

PERCEIVE	Recognize an action or situation as it evolves over time in the absence of any specific indicator, such as an aircraft deviation or a tracking fault. (cf. Detect, Observe) **R/A, VC/A**
PROJECT	Mentally extend or estimate the position and/or path of one or more mobile objects, such as aircraft or ground vehicles, in time and space. **A**
QUERY	Inquire of another person or of a computer to gain information to remove doubt, as in querying a pilot about some element of a flight plan. **E, E/R/A, A/VC, VC**
QUICK-LOOK *	Temporarily produce for observation on one's own display the data or visual presentations that are available from another workstation. (cf. Force, Request) **E, E/R**
READOUT	Acquire information from the computer on a specified item, such as range/bearing/time from an aircraft to a fix. **E/R, E/R/A, R**
REASSOCIATE *	Reposition a Data Block with its intended target when it has become disassociated from it. **E**
RECALL	Summon or otherwise return personnel to their workstations. **VC**
RECEIVE	Acquire transmitted messages by seeing or listening, without necessarily taking action to express approval or receipt. (cf. Acknowledge) **R, R/A, A/VC, VC**
RECORD	Make a permanent or written note of an event or observation, as in recording a weather observation. **E**
REDIRECT *	Retract handoff initiated to one controller and reinitiate it to another controller. **E**
REMOVE	Physically take an item away from something and place it elsewhere, such as removing a flight progress strip from its holder and putting it in a place for later retrieval and storage. **E**
REPLAY	Electronically recreate a prior situation, such as a traffic situation, from a computer recording. **E/R**
REQUEST	Ask another individual for information on, approval of, or for receipt of something. Also, direct the system to provide a function such as route readout or beacon code. (cf. Force, Quick-Look) **E, E/R, VC**

RESEQUENCE	Rearrange the order of Flight Data Entries displayed. **E**
RESTORE	Bring back into being or remove an inhibit of a function such as MSAW or the display of certain information. **E**
RETRACT *	Take back, negate, or withdraw the start of an action already begun, such as a handoff. **E, VC**
RETRIEVE	Display for reconsideration a stored item, such as a previously stored trial plan. **E**
REVERT *	Go to the use of an alternate procedure, such as backup operations. **E, A, VC, TBD**
REVIEW	Look over and study conditions or situations, or reexamine something, as in reviewing the completeness of a flight plan. Also appropriate for absorbing information to maintain a dynamic picture of present and/or future traffic, or the status of some equipment. **E/R/A, R/A, A**
SEARCH	Scan/look over a display or area to locate something, such as a particular Flight Data Entry. **R/A**
SELECT	Single out an item in preference to others on a display or panel, or pick one of several available system options or items, such as a Flight Data Entry sorting priority scheme, and inform the system of the choice. **E**
SET UP *	Adjust equipment for proper functioning. **E**
SIGN OFF	Carry out a standard procedure to inform the system that one is no longer operating at a particular control workstation. **E**
SIGN ON	Carry out a standard procedure to establish oneself as operating at a particular control workstation. **E**
SKETCH	Draw or dimension on an electronic display, as in specifying new sector airspace other than an adapted airspace. **E, A/E**
SUGGEST	Offer another course of action for consideration when a request is not feasible, such as clearance alternatives to a clearance request. **E, A/C, VC**
SUPPRESS	Curtail the display of an item, such as a Full Data Block after a pointout. Such display may be restored at some later time. (cf. Inhibit) **E**

SWITCH	Change a given system condition to another available condition, as when switching communications to a backup frequency. **E**
TERMINATE *	Bring an action to an end, as in terminating radar service to an aircraft. (A controller term used with pilots, but comparable to "Delete.") **E, VC**
TRANSFER	Direct the system to convey a Flight Data Entry from one control position to another for display and action at the latter location. **E**
UNFLAG *	Physically reposition an item to its normal position to undo its effect as a reminder, serving as the equivalent of removing a display emphasis. **E**
UPDATE	Change or modify text or data to make it more up-to-date, as in updating electronic reminder notes. **E**
VALIDATE *	Determine that an automatic altitude readout varies less than 300 feet from pilot-reported or known altitude. **R/A, A/VC**
VERIFY	Establish the truth of an activity or matter by confirming that a particular situation or matter is in the expected state. For example, verifying pilot compliance with a clearance, or confirming the occurrence of specific computer actions during transition stages. **R/A, A**

GLOSSARY OF TASK ELEMENT VERBS

Action verbs used in Task Element statements come from a specific taxonomy of terms originally documented in DOT/FAA/AP-84/18 [7]. These defined and structured terms represent the range of human actions involved in interacting with computer-based command and control systems such as the ACCC and TCCC. Task Element statements represent the most specific level of detail in describing the discrete actions successively performed to complete a Task (which is a single meaningful unit of purposeful work performed by the controller).

There are two basic sets of element action verbs:

1. Those representative of internal processes of the controller: Perceptual, Mediatory (Cognitive), and Communicative.

2. Those representative of physical control processes by which a controller interacts with the computer system and its displays. Input information to the computer takes the forms of Creating, Indicating, Eliminating, Manipulating, and Activating of data, messages, and commands.

Figure 3.5-3 presents the taxonomic structure of element action verbs within each of these categories.

PERCEPTUAL PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
ACQUIRE	GATHER IN OR PERCEIVE VIA DETECTION, SCANNING, SEARCH, EXTRACTION, OR CROSS-REFERENCE.
DETECT	Visually or aurally discern a newly occurring or recently available fact or item (not the object of preceding attention), usually from a display, workstation, or observable area or item.
SCAN	Glance over quickly, usually looking for overall patterns or anomalous occurrences.
SEARCH	Purposeful looking over a display or area to locate a specific item or items
EXTRACT	Directed, attentive reading, observing, or listening with the purpose of gleaning the meaning or contents thereof.
CROSS-REFERENCE	Accessing or looking up related information, usually by means of an indexing or organized structuring scheme set up for that purpose.
IDENTIFY	COGNITIVELY CLASSIFY VIA DISCRIMINATION OR RECOGNITION.
DISCRIMINATE	Roughly classify or differentiate an entity in terms of gross-level grouping or set membership, frequently on the basis of only a limited number of attributes.
RECOGNIZE	Specific, positive identification of an entity.

MEDIATORY PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
ANALYZE	EXAMINE METHODICALLY SO AS TO DETERMINE THE NATURE AND COMPONENTS OF A MATTER VIA CATEGORIZATION, CALCULATION, ITEMIZATION, OR TABULATION.

CATEGORIZE	Classify or sort one or more entities into specific sets or groupings, usually on the basis of a well-defined classification scheme.
CALCULATE	Reckon, mentally compute, or computationally determine.
ITEMIZE	List or specify the various components of a grouping.
TABULATE	Tally or enumerate the frequencies of occurrence or values of the members of an itemized list or table.
SYNTHESIZE	MENTALLY PRODUCE NEW INFORMATION VIA ESTIMATION, INTERPOLATION, TRANSLATION, INTEGRATION, FORMULATION, OR PROJECTION/ EXTRAPOLATION.
ESTIMATE	Mentally gauge, judge, or approximate, often on the basis of incomplete data.
INTERPOLATE	Assign an approximate value to an interim point based upon knowledge of values of two or more bracketing reference points.
TRANSLATE	Convert or change from one form or representational system to another according to some consistent "mapping" scheme.
INTEGRATE	Pull together, and mentally organize, a variety of data elements so as to extract the information contained therein.
FORMULATE	Mentally compose or prepare the content of a message or plan, including all required or pertinent elements thereof.
PROJECT/ EXTRAPOLATE	Assign an approximate value to a future point based upon the value(s) of preceding point(s). Also, mentally extend or estimate the position and/or path of one or more mobile objects in time and space.
ASSESS	CONSIDER VIA COMPARISON OR EVALUATION
COMPARE	Relate one item to another to note relative similarities and/or differences.
EVALUATE	Examine and judge the merits of an action or alternative courses of action.

DECIDE	ARRIVE AT AN ANSWER, CHOICE, OR CONCLUSION VIA ANALYSIS, SYNTHESIS, AND/OR ASSESSMENT.

COMMUNICATIVE PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
TRANSMIT	SEND OUT A MESSAGE, SUCH AS A CALL, ACKNOWLEDGEMENT, RESPONSE, SUGGESTION, DIRECTION, INFORMATION, INSTRUCTION, OR REQUEST.
CALL	Signal to a specific recipient or set of recipients that a message is forthcoming.
ACKNOWLEDGE	Respond to an originating individual or computer message indicating a call or message has been received, without further commitment as to what action will be taken.
RESPOND	Answer or reply in reaction to a message input.
SUGGEST	Offer another course of action or an alternative for consideration.
DIRECT	Provide explicit, authoritative instructions, directing that a certain action be taken.
INFORM	Pass on or relay information or data to another person.
INSTRUCT	Teach, educate, or provide remedial data.
REQUEST	Ask for information on, approval of, or for receipt of something.
RECEIVE	ACQUIRE TRANSMITTED INFORMATION BE SEEING OR LISTENING, WITHOUT APPROVING OR ACKNOWLEDGING THE CREATING PROCESSES.

CREATING PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
ASSOCIATE	ESTABLISH A REFERENCE LINK VIA NAMING OR GROUPING.
NAME	Give a title to or attach a label to, for purpose of identification or reference.
GROUP	Link together or associate for purposes of identification.
INTRODUCE	ORIGINATE OR ENTER NEW DATA INTO THE SYSTEM (E.G., TYPE IN A FREE-FORM TEXT MESSAGE).
INSERT	Make space for and place an entity at a selected location within the bounds of another such that the latter wholly encompasses the former, and the former becomes an integral component of the latter.
ASSEMBLE	PUT TOGETHER VIA AGGREGATION OR OVERLAY.
AGGREGATE	Combine two or more components so as to form a new composite entity.
OVERLAY	Superimpose one entity on top of another so as to affect a composite appearance while still retaining the separability of each component layer.
REPLICATE	REPRODUCE BY COPYING OR INSTANCING.
COPY	Reproduce one or more duplicates of an entity (i.e., with no links to the "master").
INSTANCE	Reproduce an original ("master") entity in such a way as to retain a definitional link to the master (i.e., such that any subsequent changes or modifications made to the master will automatically be reflected in each and every "instance" created therefrom).

INDICATING PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
INITIATE	OPT FOR OR CHOOSE AN ENTITY OR PROCESS (e.g., a position, message, or object) IN PREFERENCE TO OTHERS BY SELECTING IT, "POINTING" TO IT, OR OTHERWISE INFORMING THE SYSTEM OF THE CHOICE. "Initiate" can include the use of an implied function message as well as manually executing a function, without specifying the design means for the indication to the sytem.
REFERENCE	OPT FOR OR CHOOSE AN ENTITY BY INVOKING ITS OTHER IDENTIFIER.

ELIMINATING PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
REMOVE	EXCISE VIA CUTTING OR DELETION.
CUT	Remove a designated portion of an entity and place it in a special-purpose buffer. (Residual components of the original entity usually close in around the "hole" left by the "cut out" portion.)
DELETE	Erase or cancel a previous action or information item, irrevocably removing it from further consideration or display.
STOP	ARREST VIA SUSPENSION OR TERMINATION.
SUSPEND	Stop the display of an item or the occurrence of a system process and hold it in abeyance for future recall or restoration.
TERMINATE	Bring an action to an end or conclude a process such that it cannot be restarted from the point of interruption, but only by complete re-initiation.
DISASSOCIATE	ELIMINATE A REFERENCE LINK BY RENAMING OR UN-GROUPING.
NAME	Change an entity's title or label without changing the entity itself.

UN-GROUP	Eliminate the common bond or reference linkage of a group of entities.
DISASSEMBLE	PULL APART BY SEGREGATION OR FILTERING.
SEGREGATE	Partition and separate an entity into two or more component parts such that the structure and identity of the original is lost.
FILTER	Selectively eliminate one or more layers of an overlayed composite.
SUPPRESS	CONCEAL OR KEEP BACK CERTAIN ASPECTS OR PRODUCTS OF A PROCESS WITHOUT AFFECTING THE PROCESS ITSELF (i.e., affects appearance only).
SET-ASIDE	REMOVE ENTIRE CONTENTS OF CURRENT (ACTIVE) WORK AREA AND STORE IN A READILY ACCESSIBLE BUFFER FOR FUTURE RECALL.

MANIPULATING PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
TRANSFORM (CHANGE ATTRIBUTE)	MANIPULATE OR CHANGE ONE OR MORE OF AN ENTITY'S ATTRIBUTES (e.g., color, line type, character, font, size, orientation) WITHOUT CHANGING THE ESSENTIAL CONTENT OF THE ENTITY ITSELF.

ACTIVATING PROCESSES

ELEMENT VERB	DEFINITION OF OPERATOR ACTION FOR VERB
EXECUTE (______FUNCTION)	INITIATE OR ACTIVATE ANY OF A SET OF PREDEFINED UTILITY OR SPECIAL-PURPOSE FUNCTIONS (e.g., sort, merge, calculate, update, extract, search, replace). This may be an implied action by the message format previously used to input the function data.
PERFORM (TEM______)	Same as EXECUTE, but applied to a Task Element Module (TEM).

APPENDIX D

GLOSSARY OF TERMS

The following terms are used in reports of the Operations Concepts for Air Traffic Control operational positions of the National Airspace System. They are used in the sense in which they are defined here. Not all are in general use or officially recognized.

ACF BACKUP MODE (TCCC): The TCCC shall support the transitioning of the parent ACCC when the ACCC cannot provide full or reduced service. An alternate ACCC may assume the parent ACCC role.

ACF OPERATIONAL POSITIONS:

a. ACF Controller - A controller in the ACF who provides ATC service for arriving or departing VFR/IFR aircraft, or for en route aircraft.

b. Oceanic Manual Controller - A control position providing ATC services to aircraft operating in Oceanic Airspace under U.S. jurisdiction. This position will occur at the New York and Oakland ACFs.

c. Area Supervisor - Supervises the operations and the control positions of a designated area of the facility's airspace. Directly responsible to the Area Manager-in-Charge during the watch.

d. Traffic Management Coordinator - A control position that implements traffic management actions whenever it best serves the ATC system and its users. Analyzes the general traffic flow in the area, weather data, and available system status data, and recommends changes in traffic patterns to reduce traffic congestion. Issues restrictions and route changes to implement those recommendations. This position assumes the duties of the Weather Coordinator and the Metering position at certain times.

e. Area Manager-in-Charge - Directs and supervises the daily overall air traffic operations within the Area Control Facility.

f. Flight Data Monitor - The ACF position which is responsible for resolving problems in messages which the ACCC is unable to process and which are not suitable for referral to the entering position.

ACTIVE FLIGHT PLAN: A flight having met certain parameters or certain events, such as becoming airborne, which require action on the flight, taking it from an inactive to an active state.

ACTIVE SECTOR: A sector providing air traffic control in one or more assigned Fix Posting Areas.

ADAPTATION: Unique site-dependent data required by the operational program to provide the flexibility necessary to allow it to function at individual sites. Also, the unique data required to allow a Sector Suite or Tower Position Console to function as a particular Position.

ADDITIONAL AIRWAYS: Adaptation capability available in the ACF for designating a class/type function for displaying airway data that normally are not observed at the particular position. For example, a controller of a low altitude sector might desire to observe the high altitude airways, which could be displayed by dashed lines instead of the usual solid lines.

ADJACENT FACILITY: A facility whose assigned airspace borders that of the facility being discussed. This applies to an ACF bordering another ACF and to an ATCT underlying an ACF or TAAS.

ADVANCED AUTOMATION SYSTEM (AAS): The system that will replace all existing en route and terminal ATC systems, as well as provide automation in airport control towers.

ADVISORY: Advice and information provided to assist pilots in the safe conduct of flight and aircraft movement.

AERA ALERT DISPLAY: An ACF Logical Display containing information relating to alert conditions detected by the ACCC.

AERONAUTICAL AND METEOROLOGICAL (A&M) DATA DISPLAY: An ACF Logical Display that contains, in tabular format, weather and other information that affect flight operations but are not directly related to a flight.

AERONAUTICAL RADIO, INC. (ARINC): The company formed by the major airline companies to provide air-ground radio communications for dispatching information. Communications included are: push back time; departure and arrival time; gate time and data; progress reports to the company dispatcher; and weather information. This is the prime communications relay used by the Oceanic Manual Controller for oceanic flights.

AIRCRAFT CLASSES: For the purposes of Wake Turbulence Separation Minima, ATC classifies aircraft as Heavy, Large, and Small.

AIRMAN'S METEOROLOGICAL INFORMATION (AIRMET): In-flight weather advisories issued only to amend the area forecast concerning weather phenomena that are of operational interest to all aircraft and potentially hazardous to aircraft having limited capability because of lack of equipment, instrumentation, or pilot qualifications. AIRMETs concern weather of less severity than that covered by SIGMETs or Convective SIGMETs. AIRMETs cover moderate icing, moderate turbulence, sustained winds of 30 knots or more at the surface, widespread areas of ceilings less than 1,000 feet and/or visibility less than 3 miles, and extensive mountain obscuration.

AIR NAVIGATION FACILITY (NAVAID): Any facility used in, available for use in, or designated for use in aid of air navigation. Included are landing areas, lights, any apparatus or equipment for disseminating weather information, for signaling, for radio direction-finding, or for radio or other electronic communication, and any other structure or mechanism having a similar purpose for guiding or controlling flight in the air or the landing or takeoff of aircraft.

AIRPORT ACCEPTANCE RATE (AAR): An estimate of the maximum rate at which a particular airport or runway can receive incoming flights (arrivals), given the existing weather and runway conditions.

AIRPORT ENVIRONMENTAL DATA DISPLAY: An ACF Logical Display that contains data from airport environmental sensors.

AIRPORT SURFACE DETECTION EQUIPMENT (ASDE): Radar equipment specifically designed to detect all principal features on the surface of an airport, including aircraft and vehicular traffic, and to present the entire image on a radar indicator console in the control tower. It is used to augment visual observation by tower personnel of aircraft and/or vehicular movements on runways and taxiways.

AIRPORT TRAFFIC AREA (ATA): Unless otherwise specifically designated in FAR Part 93, that airspace within a horizontal radius of 5 statute miles from the geographical center of any airport at which a control tower is operating, extending from the surface up to, but not including, an altitude of 3,000 feet above the elevation of the airport. Unless otherwise authorized or required by ATC, no person may operate an aircraft within an Airport Traffic Area except for the purpose of landing at, or taking off from, an airport within that area.

AIRPORT TRAFFIC CONTROL TOWER (ATCT): A facility providing airport traffic control service to aircraft operating in the vicinity of an airport or on the movement area. There will be approximately 300 ATCTs, most with a Tower Control Computer Complex (TCCC). The TCCC will support two basic configurations of towers:

a. Towers with airport environmental data, flight data, and surveillance displays.
b. Towers with airport environmental data and flight data displays.

ATCT facilities are categorized as one of four types:

a. Radar Approach.
b. Limited Radar.
c. VFR Tower - An Airport Traffic Control Tower that does not provide approach control service.
d. TRACAB - A Tower with terminal radar approach control in the tower cab.

AIRSPACE PROXIMITY PROBE: The automatic detection of the intersection of any flight plan with special use airspace that may not be used freely by aircraft.

AIRSPACE REDEFINITION: Resectorization/reconfiguration of ACF sectors. There may be six types of airspace redefinition:

a. Global change of sector boundaries.
b. Combining/decombining of sectors.
c. Splitting a sector.
d. Redefining of airspace boundaries.
e. ACCC backup.
f. Reconfiguration of sectors to Sector Suites.

Another form of reconfiguration is position change at a Sector Suite workstation.

AIR TRAFFIC CLEARANCE: An authorization by Air Traffic Control, for the purpose of preventing collision between known aircraft, for an aircraft to proceed under specified traffic conditions within controlled airspace.

AIR TRAFFIC CONTROL (ATC): A service that promotes the safe, orderly, and expeditious flow of air traffic, including airport, approach, and en route air traffic control.

ATC FACILITY: A facility that provides air traffic control service.

AIR TRAFFIC CONTROLLER: A person authorized to provide air traffic service.

AIR TRAFFIC CONTROL RADAR BEACON SYSTEM (ATCRBS): See Radar Beacon ATCRBS (Secondary Radar).

AIRWAY: A control area or portion thereof, established in the form of a corridor, the outline of which is defined by radio navigation aids.

ALERT AND RESOLUTION DISPLAY: A Logical Display that contains information for the immediate attention of the controller or supervisor.

ALTIMETER SETTING: The barometric pressure reading used to adjust a pressure altimeter for variations in existing atmospheric pressure or to the standard altimeter setting (29.92).

ALTITUDE RESERVATION (ALTRV): Airspace utilization under prescribed conditions normally employed for the mass movement of aircraft or other special user requirements that cannot be accomplished by other means. ALTRVs are approved by the appropriate FAA facility.

ALTITUDE RESTRICTION: An altitude or altitudes stated in the order flown which are to be maintained until reaching a specific location or time. Altitude restrictions may be issued by ATC because of traffic, terrain, or other airspace considerations.

AREA CONTROL COMPUTER COMPLEX (ACCC): The common automation system equipment and software that support control of aircraft in a specific area; located within each Area Control Facility. The ACCC is one portion of the AAS.

AREA CONTROL FACILITY (ACF): The planned 23 facilities that will result from consolidation of existing ARTCC and TRACON/TRACAB facilities. An ACF may be formed from an existing ARTCC or may be created in a new building. The number, location, and implementation dates of ACFs will be in accordance with the National Airspace System Plan. There would be 20 CONUS ACFs converted from ARTCCs; plus Honolulu, Anchorage, and the New York TRACON. Each will eventually accomplish all en route and approach/departure control.

ARINC MESSAGE DISPLAY: An ACF Logical Display containing all the information referred to the Oceanic Controller from the processing of ARINC messages.

ASSIGNED ALTITUDE: The current authorized altitude for an active flight. An assigned altitude is given to a flight upon initial clearance delivery, but can be modified by controllers.

ASSOCIATION: The process whereby a track position is compared with a position interpolated from the flight plan to determine whether the flight is in conformance with the flight plan.

ATCCC FORECAST: Operational and delay information, pertinent weather data and their effects on operations, and other significant events affecting operations, as passed from the ATCCC to the ACF.

ATCT OPERATIONAL POSITIONS:

1. Typical of less busy ATCTs:

   a. Supervisory position - Provides first-level supervision, plans and coordinates the work of the ATCT air traffic control specialists, and is responsible for directing operations of an assigned watch.

   b. Local Control position - Local Control duties involve sequencing, spacing, and issuing clearances and instructions to aircraft operating in the Tower's area of responsibility. The controller considers: the position, type, speed, and direction of movement of aircraft desiring to land; estimate of future position; the number and capabilities of aircraft wishing to depart from the airport; the pattern, length, direction, and condition of runways available for use; wind speed and direction; noise abatement requirements; wake turbulence; and traffic information. The controller may provide special VFR services and traffic and weather advisories. Visibility observations are made and reported to pilots and other control positions.

   c. Ground Control position - The position responsible for controlling the movement of aircraft and other vehicles on all parts of the airport and movement area except the runways in use. Ground Control duties include: formulating and issuing taxi clearances and instructions, coordinating with the Local Control position as necessary for taxiing across active runways; maintaining separation among taxiing aircraft and vehicles; monitoring and analyzing ground traffic; directing the movement and positioning of emergency and maintenance equipment.

d. Flight Data position - The position responsible for receiving flight plans and entering information as required, and relaying data to the appropriate IFR facility or tower position. In addition, this position is responsible for obtaining/formulating clearances for IFR/VFR flights and making them available for delivery to aircraft. Weather reports and NOTAMs are relayed to other positions of operation and to other facilities, to include updating of the ATIS broadcast.

2. Typical of busier ATCTs:

a. All of the above positions will be found in busier ATCTs, with the possibility of Local and Ground Control responsibilities being shared by an additional controller or controllers. Possible additional positions are cited below.

b. Clearance Delivery position - When not combined with the Flight Data position, this position is responsible for issuing clearances, transponder codes, and frequency information to pilots prior to departure. At some high activity towers, flow management (e.g., EDCTs, gate holds) also is a responsibility.

c. Cab Coordinator position - This position provides liaison between operating positions (both interfacility and intrafacility).

d. Other special operation positions - There are several types of Assistant Local Control positions possible, to handle specialized operations. These include Approach Control, Handoff, and Helicopter. Other specialized positions may include Traffic Management and Gate Hold. As described in this document, Local Control, Ground Control, Clearance Delivery/Flight Data, and the Tower Supervisor duties include all tasks of the Cab Coordinator and other special operations positions.

e. Traffic Management Coordinator - The TCCC position responsible for implementing local flow programs in conjunction with national programs to smooth peaks and valleys in traffic flow, thus providing metering/spacing of aircraft.

AUTOMATED EN ROUTE AIR TRAFFIC CONTROL (AERA): The enhanced ATC automation system of the future.

AUTOMATED RADAR TERMINAL SYSTEM (ARTS): Computer-aided radar display subsystems capable of associating alphanumeric data with radar returns. Systems with varying functional capability, determined by the type of automation equipment and software, are denoted by a number/letter suffix following the name abbreviation.

AUTOMATIC TERMINAL INFORMATION SERVICE (ATIS): Message consisting of recorded non-control information in selected terminal areas. A continuous broadcast of ATIS messages is transmitted by radio. Its purpose is to improve controller effectiveness and to relieve frequency congestion by automating the repetitive message broadcasts.

AUTOMATIC TRAFFIC COUNT DISPLAY: A Logical Display that is capable of displaying airport operations data, and peak day data according to the categories of airport operations. In ACFs it contains the traffic count data by sectors and by categories of aircraft operations.

BASE OPERATIONS (BASOPS): The military equivalent of a combined airline dispatch office and FAA Flight Service Station. BASOPS provides flight plan filing, weather briefings, and other pilot related services.

CLEARANCE/APPROVAL: An originating position may coordinate a clearance for the approval of an adjacent sector or facility if the flight will presently enter the adjacent sector's or facility's airspace.

CLEARED FOR THE OPTION: ATC authorization for an aircraft to make a touch-and-go, low approach, stop-and-go, or full stop landing at the discretion of the pilot. It is normally used in training so that an instructor can evaluate a student's performance under changing conditions.

CLEARED TO LAND: ATC authorization for an aircraft to land. It is predicated on known traffic and known physical airport conditions.

COMBINING/DECOMBINING: Adapting to traffic loads. One or more sectors or positions are combined when converting from day to night watches or to adjust controller workload. This is a short-term operational rearrangement of sectors or positions and does not involve any change in wiring to the positions.

COMMUNICATIONS RELAY: A term used to indicate controller communications to and from the pilot of an oceanic flight through a third party, which usually is Aeronautical Radio, Inc. (ARINC) or a military facility (BASOPS).

CONFLICT ALERT: A function of ATC automated systems designed to alert radar controllers to existing or pending aircraft conflict situations that require immediate attention/action.

CONFLICT ALERT IMMEDIATE SUMMARY DISPLAY: An ACF Logical Display that contains information generated by the violation reporting function.

CONFLICT RESOLUTION ADVISORY: System-generated alternatives for the resolution of conflicts identified by either the Conflict Alert or MSAW functions.

CONFORMANCE: A determination that an agreement within tolerance exists between an assigned and reported item, such as altitude conformance.

CONTROL AREA (CTA): The airspace within a Flight Information Region (FIR) designated as controlled airspace.

CONTROLLED AIRCRAFT: Aircraft that are participating in and receiving traffic separation service from the ATC system.

CONTROLLER NOTEPAD DISPLAY: A Logical Display that contains controller or supervisor-entered free-form text notes, serving as a personal electronic scratch pad for each position. These notes are not eligible for transfer to another position.

CONTROL SECTOR: An airspace area of defined horizontal and vertical dimensions for which a controller, or group of controllers, has an air traffic control responsibility. Sectors are established based on predominant traffic flows, altitude strata, and controller workload. Pilot-controller communications during operations within a sector normally are maintained on discrete frequencies assigned to the sector.

DATA BLOCK: There are three forms of data blocks associated with target tracks: Full, Partial, and Limited.

A Full Data Block (FDB) is a multi-line block of control data displayed on the Situation Display of the controlling sector or position for each controlled aircraft. It contains system data, flight data, and radar-derived control data which may include all specified data block information. Full Data Blocks will be displayed at the receiving sector or position as a result of handoff or pointout action. Full Data Blocks may be quick-looked by another position.

A Partial Data Block (PDB) is a multi-line block of control data displayed on the Situation Display of a sector or position that has requested to observe some of the Full Data Block data of another sector or position. It contains system, flight plan, and radar-derived data

which may include all specified data block information. It will not contain callsign data. It will almost always be established to display at least altitude information.

A Limited Data Block (LDB) is a multi-line block of data on the Situation Display of any sector or position that has requested to observe, through filter selection, target and radar data not associated by the system with flight plan data.

DATA BLOCK OFFSET: The distance and direction of the data block with respect to the target. The data block is attached to the corresponding target by a line called a leader. An automatic data block offset algorithm will be implemented in the AAS.

DEVIATION: An unauthorized departure by a pilot from a current clearance, such as an off-course maneuver to avoid weather or turbulence. Also, unauthorized movement or parking of landed aircraft and ground vehicles on runways or taxiways.

DISCRETE BEACON CODE: A unique train of electronic pulses transmitted by an aircraft transponder in reply to a radar beacon interrogator. A four-digit octal code in which one or both of the last two digits is other than zero.

EXPANDED QUOTA FLOW (EQF): A traffic management procedure by which the Central Flow Control Function (CFCF) restricts traffic to the ACF area having an impacted airport, thereby avoiding sector/area saturation.

EXPECT DEPARTURE CLEARANCE TIME (EDCT): A Traffic Management constraint indicating the runway release time assigned to an aircraft in a controlled departure time program.

FIX: A geographical point on an airway used for aircraft navigation and/or position reporting.

FIX POSTING AREA (FPA): A volume of airspace, bounded by a series of connected line segments with altitudes, which is assigned to a sector.

FLIGHT CHECK: A callsign prefix used by FAA aircraft engaged in flight inspection/certification of navigational aids and flight procedures.

FLIGHT DATA DISPLAY: A Logical Display that provides flight information to controller positions assigned to a sector, aircraft under a Tower's control or jurisdiction, or otherwise of interest to the sector or Tower.

FLIGHT DATA ENTRY (FDE): A set of flight plan data for one aircraft shown on the Flight Data Display. One FDE is analogous to one paper flight progress strip in the current system.

FLIGHT DATA ENTRY NOTATION (FDEN): A controller-entered or machine-generated symbol on a field in the Flight Data Entry which indicates a certain condition for the particular flight. FDENs are the AAS replacement for the current flight strip marking procedures. Some FDENs may be transferred automatically with the FDE to another control position.

FLIGHT DATA MONITOR DISPLAY: An ACF Logical Display containing referrals on messages which the ACCC is unable to process and which are not suitable for referral to the entering position.

FLIGHT DATA READOUT: Flight data on one particular flight that is chosen by the controller or supervisor and is displayed in the Flight Data Readout Area.

FLIGHT INFORMATION REGION (FIR): An airspace of defined dimensions within which Flight Information Service and Alerting Service are provided.

FLIGHT LEVEL (FL): A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each is stated in three digits that represent hundreds of feet. For example, flight level 250 represents a barometric altimeter indication of 25,000 feet.

FLIGHT PLAN: Information relating to an intended flight of an aircraft that is filed either orally or in writing with an ATC facility or Flight Service Station.

FLIGHT SERVICE STATION (FSS): An Air Traffic facility which provides such services as pilot briefings, receiving and processing of IFR flight plans, relaying of ATC clearances, broadcasts of aviation and NAS weather information, origination of Notices to Airmen, and VFR search and rescue.

FORCE: A feature that provides the controller or supervisor with the capability to display a Full Data Block on a particular aircraft.

FULL DATA BLOCK (FDB): A block of alphanumerics associated with a target shown on the Situation Display. Full Data Blocks are shown for aircraft under the control of a sector or position, or of particular interest to the sector or position. (see DATA BLOCK)

FULL PERFORMANCE LEVEL (FPL) CONTROLLER: An Air Traffic Control Specialist at the highest controller grade in a particular facility who has been certified to operate all positions required for reaching that grade level in that facility. An FPL controller is sometimes called a Journeyman Controller.

HANDOFF: A controller action taken to transfer the radar identification of an aircraft from one controller to another if the aircraft will enter the receiving controller's airspace and radio communications with the aircraft will be transferred.

IMPEDIMENT: A potential physical or weather hazard/obstacle that could interfere with normal flight, such as tethered balloons, antennas, weather cells, terrain, or military maneuvers.

INSTRUMENT FLIGHT RULES (IFR): See Federal Aviation Regulations (FAR) that govern the procedures for conducting instrument flight (FAR Part 91).

INTERFACILITY: Between facilities; for example between one ACF and another, or between an ACF and an ATCT. (cf. INTRAFACILITY)

INTERIM ALTITUDE: An altitude clearance providing a temporary altitude assignment prior to the issuance of a final altitude clearance. It is used to stop an aircraft's climb or descent in traffic.

INTRAFACILITY: Within a single facility; for example, between two sectors within the same ACF. (cf. INTERFACILITY)

LIMITED DATA BLOCK (LDB): A block of alphanumerics associated with a target shown on the Situation Display. Limited Data Blocks are shown for aircraft under position control or of interest to a position but not under control of the position. They contain beacon code, altitude, and ground speed. (see DATA BLOCK)

LIMITED/STANDARD FLIGHT PLAN: A Flight Data Entry (Entries) which may be displayed in an abbreviated or normal fashion, depending on whether the flight is actively being controlled by the sector. Standard flight plan display contains all normal elements of a Flight Data Entry but may have the route portion presented in a truncated or tailored fashion. Further abbreviation or deletion of elements may occur after the associated track is displayed by the sector.

LOCAL COMMUNICATION NETWORK (LCN): A communication system used to interface devices and Sector Suites within the ACF.

LOGICAL DISPLAY: A set of information displayed at a position as a single entity. The following Logical Displays are specified for both the ACF and the ATCT:

Situation Display
Flight Data Display
Alert and Resolution Display
Special Lists
Message Composition and Response Display
Static Information Display
Controller Notepad Display
Automatic Traffic Count Display

Logical displays unique to the ACF are:

Aeronautical and Meteorological Data Display
Airport Environmental Data Display
System Status Data Display
Weather Display
Traffic Management Situation Display
Traffic Management Flight Data Display
Oceanic Situation Display
Traffic Management Coordinator Display
Sector Workload Display
Conflict Alert Immediate Summary Display
ARINC Message Display
AERA Alert Display
Suppressed Display List Display
Flight Data Monitor Display

Logical Displays unique to the ATCT are:

System Environmental and Status Data Display
Supervisory/Maintenance Data Display

MESSAGE COMPOSITION AND RESPONSE DISPLAY: A Logical Display that contains menus for the composition of messages and an area for the system's response.

MINIMUM ASSIGNABLE FLIGHT LEVEL: The minimum allowable flight level that a controller can give an aircraft. It is calculated from the current barometric pressure.

MINIMUM SAFE ALTITUDE WARNING (MSAW): A function of the computer that aids the controller by an alert when a tracked Mode C-equipped aircraft is below or is predicted by the computer to go below a predetermined minimum safe altitude.

MODE C: An interrogation mode in which a beacon radar transponder automatically reports altitude when interrogated by a ground station.

MODE 3/A: An interrogation mode in which a beacon radar transponder automatically reports identification when interrogated by a ground station.

MODE S: A surveillance system which also will provide a digital data link with properly equipped aircraft.

MODES OF OPERATION (ACCC):

a. Operational Mode - ACCC performs all designated functions for its designated airspace.

b. Failsoft Mode - ACCC temporarily may discontinue some functions when not enough processing power is available to sustain the Operational Mode.

c. Emergency Mode - A contingency mode, used to give continuity during the transition to facility backup.

MODES OF OPERATION (TCCC):

a. Normal Mode - The TCCC accepts target data, maintains track data, and provides for the display of Separation Assurance alerts. The TCCC also accepts and maintains flight data and weather data received from its parent ACCC. The TCCC distributes and displays these data at Tower control positions. The TCCC also collects, processes, distributes, and displays local airport environmental data and transmits them to the parent ACCC.

b. Stand-Alone Mode - The TCCC transitions to the Stand-alone Mode of operation when communications with the parent ACCC become unavailable. In the Stand-alone Mode, the TCCC performs limited surveillance processing functions and continues to provide those flight data processing functions that do not require communications with the ACCC (e.g., transfer of flight data from one Tower position to another). Airport environmental data processing and display capabilities in the Stand-alone Mode are the same as specified for the Normal Mode, except that environmental data are not transferred between the TCCC and ACCC.

MOVEMENT AREA: The runways, taxiways, and other areas of an airport that are used for taxiing, takeoff, and landing of aircraft, exclusive of loading ramp and parking areas.

NATIONAL DATA INTERCHANGE NETWORK (NADIN): A communication network between various types of ATC facilities. Its implementation will involve decommissioning of the existing low-speed teletypewriter networks.

NATIONAL AIRSPACE SYSTEM (NAS): The common network of U.S. airspace; air navigation facilities, equipment, and services; airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information, personnel, and material. Included are system components shared jointly with the military.

NONCONFORMANCE: Computer determination that an agreement within tolerance no longer exists between an assigned and a reported item, such as altitude entered into the system versus a Mode C report, or a route trajectory calculated by the system versus a radar track position.

NON-CONTROLLED AIRCRAFT: Those aircraft not participating in or receiving traffic separation service from the ATC system. This term does not include those flights receiving control service from control Towers having only visual surveillance in performing control service. This term includes unidentified aircraft penetrating TCA, TRSA, ARSA, etc.

NON-CONTROLLED OBJECT: Non-controlled aircraft such as ultralights and radio-controlled aircraft as well as other objects that are on the ground or in the air in such a way as to pose a possible hazard to airport operations or controlled flights. These other objects may include flocks of birds, untethered balloons, animals near runways, etc.

NON-DISCRETE CODE: A radar beacon Mode 3/A assigned to more than one aircraft within a specific geographic area. Currently, a four-digit octal code in which the last two digits are zeros.

NOTICE TO AIRMEN (NOTAM): A notice containing information (not known sufficiently in advance to publicize by other means) concerning the establishment, condition, or alteration of any component (facility, service, or procedure of, or hazard in the National Airspace System), the timely knowledge of which is essential to personnel concerned with flight operations.

OCEANIC DISPLAY AND PLANNING SYSTEM (ODAPS): A proposed system consisting of a flight data processor and displays for use at the two ARTCCs that engage in control of aircraft over the ocean. The ACCC will have processing and display equipment which will replace the ODAPS.

OCEANIC FLIGHT PLAN POSITION EXTRAPOLATION (OFPPE): Computer prediction of an aircraft's future flight trajectory based on calculation of its present position and projection of the flight path ahead for some parameter time. In the oceanic (nonradar) environment, this process is highly dependent on pilot position reports (including pilot-reported or controller-entered headings/deviations), flight plan and flight plan amendments of speed/altitude/route, and winds aloft. It differs somewhat from the analogous domestic function in its greater length of look-ahead time and its dependence on digital position reports (from ARINC interface and other sources) in lieu of radar positioning. OFPPE is analogous to the refinements of improved coast-mode tracking through flight plan extrapolation. It allows for dynamic (simulation) control of tracking through manual/automatic headings and automatic positioning updated by pilot/controller position reports.

OCEANIC-MODE HANDOFF: A handoff of a Full Data Block using the OFPPE algorithm for track positioning.

OCEANIC-MODE POINTOUT: A pointout of a Full Data Block using the OFPPE algorithm for track positioning.

OCEANIC SITUATION DISPLAY: An ACF Logical Display that contains the plan view of oceanic airspace. Contains extrapolated aircraft locations instead of real time radar targets.

PACING AIRPORTS: Airports selected on the basis of generating the preponderance of air traffic delays within the ATC system.

PAIRING: The process whereby it is determined that both a flight plan and a track exist for a flight.

PARENT ACF: The ACF that is exchanging ATC operational data with an ATCT. It is also the ACF that is providing approach/departure services for the ATCT's airport.

PILOT WEATHER REPORT (PIREP): A report of meteorological phenomena encountered by aircraft in flight.

POINTOUT (RADAR POINTOUT): Used between controllers to indicate radar action where the initiating controller plans to retain communications with an aircraft penetrating the other controller's airspace and additional coordination is required.

POSITION: Location of aircraft. Different types of positions are defined below:

a. Target Position is the position reported by the common digitizer. It is presently received in the Host Computer System in polar coordinates (range and azimuth) and converted to the stereographic grid and then to display coordinates.

b. Track Position is the position predicted for the next scan radar return by the tracking algorithm.

c. Flight Plan Position is the position determined from filed speed converted to estimated ground speed using wind data, route of flight, and elapsed time since the flight became active.

PRECOORDINATED RELEASE: An aircraft release not requiring that the ACF be asked.

PROGRESS REPORT: A report over a known location as transmitted by a pilot to ATC. Also called POSITION REPORT.

QUICK LOOK: A feature that provides the controller or supervisor with the capability to display *Full Data Blocks* of tracked aircraft from other control positions. The quick-looked data are suppressed automatically after a system parameter time, if not terminated previously by command of the controller or supervisor.

RADAR BEACON: A radar receiver-transmitter aboard an aircraft that transmits a coded signal whenever its receiver is triggered by an interrogating radar. The coded reply can be used to determine position in terms of range and bearing from the beacon. Also called BEACON, RADAR, and RADAR TRANSPONDER.

RADAR BEACON ATCRBS (SECONDARY RADAR): A radar system in which the object to be detected is fitted with cooperative equipment in the form of a radar receiver/transmitter (transponder). Radar pulses transmitted from the searching transmitter/receiver (interrogator) site are received in the cooperative equipment and used to trigger a distinctive transmission from the transponder. This latter transmission, rather than a reflected signal, is then received back at the transmitter/receiver site for processing and display at an ATC facility.

RADAR SERVICE: A term that encompasses one or more of the following services, based on the use of radar, which can be provided by a controller to a radar-identified aircraft.

a. Radar Separation - Radar spacing of aircraft in accordance with established minima.

b. Radar Navigational Guidance - Vectoring aircraft to provide course guidance.

c. Radar Monitoring - The radar flight-following of an aircraft whose primary navigation is being performed by its pilot to observe and note deviations from its authorized flight path, airway, or route. This includes noting the aircraft's position relative to approach fixes.

REAL TIME WEATHER PROCESSOR (RWP): A system that will process current weather radar and alphanumeric and graphic weather data for use in ATC facilities.

REQUESTED ALTITUDE: An altitude requested by the pilot if filing an IFR flight plan, or an altitude change requested while en route.

RESTRICTED AREA: Airspace designated under Part 73 of the Federal Aviation Regulations within which the flight of aircraft, while not wholly prohibited, is subject to restrictions.

RUNWAY CONDITION: Includes information on such matters as Runway Visual Range, runway visibility, wind, and braking action.

RUNWAY CONFIGURATION: Information stating which runways are in use for approaches and departures.

RUNWAY VISIBILITY: The distance down the runway that a pilot can see unlighted objects or unfocused lights of moderate intensity.

RUNWAY VISUAL RANGE (RVR): The horizontal distance down a runway that a pilot can see high intensity lights. Measurement in hundreds of feet is made near the touchdown point, midpoint, and roll out point of an instrument runway.

SAFETY ALERT: Terminology change replacing "safety advisory," as distinct from "traffic advisory," "weather advisory," etc.; indicates presence of conflict alert or MSAW.

SEARCH AND RESCUE (SAR): A service that seeks missing aircraft and assists those found to be in need of assistance. It is a cooperative effort using the facilities and services of available federal, state, and local agencies. The U.S. Coast Guard is responsible for coordination of search and rescue for the Maritime Region and the U.S. Air Force is responsible for search and rescue for the Inland Region. Information pertinent to search and rescue is passed through any air traffic facility or transmitted directly to the Rescue Coordination Center by telephone.

SECTOR SUITE (S/S): Refers to the composition of functions that directly comprise either the ACF controller man-machine interface (MMI) or Sector Suite Console/Support processing elements.

SECTOR SUITE WORKSTATION: A group of consoles containing displays and input devices whereby ATC specialists (controllers or supervisors) interface with the ACCC.

SEMI-AUTOMATIC FLIGHT INSPECTION (SAFI): An FAA function to provide flight safety inspections by FAA aircraft of NAVAIDs and sensors.

SEPARATION: In Air Traffic Control, the spacing of aircraft to achieve their safe and orderly movement in flight and while landing and taking off.

SEQUENCING: Control of aircraft in a manner that provides a stream of properly spaced aircraft arriving at a fix or airport at a rate which can be accepted by adjacent ATC facilities or airports. Also, the comparable ground flow to the assigned active runway for aircraft ready to depart.

SEVERE WEATHER AVOIDANCE PLAN (SWAP): An approved plan to minimize the effect of severe weather on traffic flows in affected terminal and/or ACF areas. SWAP normally is implemented to provide the least disruption to the ATC system when flight through portions of airspace is difficult or impossible because of severe weather.

SIGNIFICANT METEOROLOGICAL INFORMATION (SIGMET): A weather advisory issued concerning weather significant to the safety of all aircraft. SIGMET advisories cover severe and extreme turbulence, severe icing, and widespread dust or sandstorms that reduce visibility to less than 3 miles.

SITUATION DISPLAY: A Logical Display that contains the plan view of sector or Tower airspace and some adjacent airspace. It contains real-time positions of targets and weather.

SPECIAL LISTS: A Logical Display that contains several lists of information in a compact and concise form. Each Special List can be independently displayed and positioned at the Sector Suite or Tower Position Console. The lists at each position are tailored to the airspace and traffic of interest to that position.

SPECIAL USE AIRSPACE: See FAA Order 7110.65, Air Traffic Control Handbook, Pilot/Controller Glossary.

SQUAWK: To activate specific modes, codes, or functions on the aircraft transponder; e.g., "Squawk three/alpha, two one zero five, low."

START TRACK: A message that requires the computer to track an aircraft and display a Full Data Block.

STATIC INFORMATION DISPLAY: A Logical Display that contains graphic and tabular data that are updated infrequently, such as area charts and procedures.

SUPERVISORY/MAINTENANCE DATA DISPLAY: An ATCT Logical Display that contains information required by supervisors and maintenance personnel to monitor the status of the TCCC resources and configurations, TCCC interfaces, TCCC performance, and the results of certification and diagnostic tests.

SUPPRESSED DISPLAY LIST DISPLAY: An ACF Logical Display containing a list of currently suppressed Logical Displays.

SYSTEM ENVIRONMENTAL AND STATUS DATA DISPLAY: An ATCT Logical Display that contains dynamic information on the status of ATC equipment, operational areas, airport equipment, etc. It also contains, in tabular form, weather and airport environmental data that affect flight operations but are not directly related to a flight.

SYSTEM STATUS DATA DISPLAY: An ACF Logical Display that contains dynamic information on the status of ATC equipment, operational areas, airports, etc.

TARGET: The indication shown as a radar display resulting from a primary radar return or a radar beacon reply.

TOWER COMMUNICATIONS SYSTEM (TCS): A system that will control voice ground-to-ground communications in the Tower facility (intercom) and between facilities (interphone), and ground-to-air communications between air traffic controllers and pilots/airport vehicle operators (radio).

TOWER CONTROL COMPUTER COMPLEX (TCCC): The equipment and software that provide ATC automation support to the controllers located in Tower Cabs. The TCCC is one portion of the AAS.

TOWER POSITION CONSOLE (TPC): Refers to the composition of functions that directly comprise either the controller/supervisor MMI or Tower Position Console/Support processing elements.

TRACK: A set of predicted points correlated with the radar returns for the flight.

TRACKING: A process that uses primary/beacon radar data and paired flight data (if any) to determine the actual position and velocity of a flight. Radar target identification through manual or automatic means; positional agreement of a radar target and the computer-predicted position; computation of the difference between the predicted position and the actual position of the radar target.

TRAFFIC:

1. A term used by a controller to transfer radar identification of an aircraft to another controller for the purpose of coordinating separation action. Traffic is normally issued in response to a handoff or pointout, in anticipation of a handoff or pointout, or in conjunction with a request for control of an aircraft.

2. A term used by ATC to refer to one or more aircraft.

TRAFFIC ADVISORIES: Advisories issued to alert pilots to other known or observed air traffic that may be sufficiently close to the position or intended route of flight of their aircraft to warrant attention.

TRAFFIC CONGESTION: A concentration of air traffic that is of such volume or complexity as to require further action to relieve the situation.

TRAFFIC MANAGEMENT COORDINATOR DISPLAY: An ACF Logical Display that contains data needed by the Traffic Management Coordinator.

TRAFFIC MANAGEMENT FLIGHT DATA DISPLAY: An ACF Logical Display that contains flight information on aircraft of interest to the Traffic Management position. This display is similar to the Flight Data Display except that the controller can request the posting of lists of FDEs in certain additional categories.

TRAFFIC MANAGEMENT RESTRICTION: A control measure designed to apply Traffic Management Advisories to individual aircraft to adjust the flow of traffic into a given airspace, along a given route, bound for a given route, or bound for a given airport, so as to ensure the most effective utilization of airspace. Airborne and ground holds, as well as aircraft speed adjustments, are some of the techniques used on an aircraft to meet traffic management restrictions. Traffic Management Advisories include in-trail restrictions, routings, flow restrictions, meter times, altitude constraints, and other flow restrictions.

TRAFFIC MANAGEMENT SITUATION DISPLAY: An ACF Logical Display that contains the plan view of airspace and aircraft of interest to the Traffic Management position.

TRANSFER OF CONTROL: The action whereby control responsibility for an aircraft is transferred from one controller to another.

TRANSIENT FAILURE: An intermittent failure or interference of short duration.

TRANSITION ALTITUDE: A Mode C altitude determined by the program to be a reported altitude for a descending or ascending flight.

TRANSPONDER: The airborne radar beacon receiver/transmitter portion of the Air Traffic Control Radar Beacon System (ATCRBS) which automatically receives radio signals from interrogators on the ground, and selectively replies with a specific reply pulse or pulse group only to those interrogations being received on the mode to which it is set to respond.

VECTOR: A heading issued to a pilot to provide navigational guidance by radar.

VISUAL FLIGHT RULES (VFR): Visual flight in which avoidance of collision with other aircraft is dependent upon every pilot seeing other aircraft and avoiding them. To enable pilots to perform the collision avoidance function, the rules take certain weather conditions into account, and specify basic "rules of the air."

VISUAL METEOROLOGICAL CONDITIONS: Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling equal to or better than specified minima.

VOICE SWITCHING AND CONTROL SYSTEM (VSCS): A system that will control voice ground-to-ground communications in the same ACF facility (intercom) and between facilities (interphone), and air-to-ground communications between air traffic controllers and pilots (radio).

WEATHER: A description of atmospheric conditions as of a specific time. This description could include: wind speed and direction; temperature; dew point; barometer reading; precipitation type and amount; cloud cover; etc.

WEATHER DISPLAY: An ACF Logical Display that contains graphic weather products from National Weather Service radars or meteorologists.

WIND SHEAR: A change in wind speed and/or wind direction in a short distance resulting in a tearing or shearing effect. It can exist in a horizontal or vertical direction and occasionally in both.

ATCT Facility Description Form

Date: ______ Time Period: _______ Weather Conditions: ___________ Rater: ________

Facility: ________________________________

I. Tower Cab Controller's Operational Environment

Tower Operating Hours:

24 Hours Other _______

Peak Traffic Periods:

Days __________

Times __________

Runway Layout:

Number of Runways _______

Diagram ? Yes No

II. Tower Level/Type/Staffing (Circle Where Appropriate)

Level:

5 4 3 2 1

Type:

VFR Limited Radar Radar Other ___________

Staffing Configurations:

Mode ------	Local Controller	Ground Controller	Clearance Delivery	Flight Data	Cab Coord	Supervisor
Normal	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1
Reduced	0 1 2	0 1 2	0 1 2	0 1 2	0 1	0 1

Traffic Types:

_____% (AC) Air Carrier

_____% (M) Military

_____% (GA) General Aviation

_____% (ST) Student Pilots

_____% (OT) Other a) __________ b) __________ c) __________

Figure E-1. Facility Description Form

III. Types of Equipment (Circle)

Radar Equipment:	Flight Data Processing:	Weather:
1. BRITE Radar	1. Strips	1. Telographer
2. BRITE A/N Subsystem (BANS)	2. FDEP	2. LLWAS
3. BANS & DUKI (Keyboard Input)		3. Altimeter
		4. Wind Instruments
		5. Wind Socks

IV. Miscellaneous

Weather Observation Source

NWS FSS Tower Other ________

Noise Abatement Problems Impacting Runway Use:

____

____

____

____

Sector Dimensions/Height:

____

____

Other Operational Constraints or Local Peculiarities
(Mountains, Restricted Airspace, Nearby Airports/Traffic, Etc.):

____

____

____

____

Figure E-1. Facility Description Form (continued)

TCCC
Quick Reference Event List

Clearance

1) Clearance Request
2) Clearance Delivery
3) TCA/TRSA/ARSA

Flight Status

4) Entering/Leaving Airborne Hold
5) Entering/Leaving Inbound Ground Hold
6) Entering/Leaving Outbound Ground Hold
7) Filed Flight Plan
8) Initial Contact
9) Aircraft Enters ATA
10) Overdue Aircraft
11) Flight Following Request
12) Flight Plan Deviation
13) Missed Approach/Go Around/ Practice Approach
14) Local Traffic
15) Pilot Request for Lighting
16) Manipulation
17) Aircraft/Vehicle Crossing Active Runway

Tranfer Control

18) Aircraft to Edge of ATA (Control Zone)
19) Airspace/Movement Area Release
20) Handoff Receipt
21) Pointout Receipt
22) Aircraft/Vehicle Entering/Leaving Area of Position Responsibility
23) Facility Closure
24) Facility Reopening

Aircraft Anomalies

25) Aircraft Emergency - Airborne
26) Aircraft Emergency/Accident/Incident - Ground
27) No Radio

Conflict

28) Aircraft-Vehicle Conflict
29) Vehicle-Vehicle Conflict
30) Impending Airspace Conflict
31) Minimum Safe Altitude Conflict
32) Aircraft-Aircraft Conflict
33) Special Use Airspace
34) Airspace Intrusion by a Non-Controlled Object

Military and Other Special Operations

35) Balloon, Glider
36) Bomb Threat
37) Hazardous Cargo (e.g., DOE Flight)
38) Experimental Flight
39) Fuel Dumping, Jettison
40) Helicopter Operation
41) Hijack
42) Law Enforcement
43) Lifeguard Mission
44) Special Interest Flight
45) SAFI Flight Check
46) Airshow
47) Medical Emergency
48) Military Operation
49) Runway/Taxiway Incursion by Obstacle/ Vehicle/Aircraft

Traffic Flow Management

50) Flow Management
51) Runway Configuration Change
52) Runway Condition Change
53) Sequencing
54) Runway/Taxiway Open/Close
55) Change Flow Pattern

System Failure/Degradation

56) TCCC Failure
57) ACCC Failure
58) Communication Failure
59) Transient Computer Failure
60) NAVAID Failure
61) Tower Position Console Failure
62) Radar Surveillance Sensor Failure
63) Airport Equipment Failure
64) Transient Communication Failure

Weather

65) Ceiling Height Report
66) Severe Weather
67) Pressure Display/Report
68) SIGMET/AIRMET
69) Visibility Report/Observation
70) Wind Speed/Direction Report/Observation
71) Wind Shear Report/Observation
72) PIREP

Position Management

73) Position Relief
74) Controller Overload
75) Position Consolidation/Deconsolidation

Note:

O - Circle indicates event was observed

√ - Check indicates event was not observed but is expected

X - An "X" indicates event never occurs in tower environment

— - A "—" indicates event is only applicable to TCCC

Figure E-2. Quick Reference Event List

Possible Tasks of the ATCT Controller Positions (As Yet Not Fully Validated)

Tower: ______________________________

Position(s) Performing
LC = Local Control
GC = Ground Control
CD/FD = Clearance Delivery/ Flight Data
CS = Cab Supervisor

Discuss SWAP procedures with terminal control	LC	CD/FD	GC	CS
Inform fire station of ground emergency/incident	LC	CD/FD	GC	CS
Detect aircraft mechanical problem/fire/smoke on landing/ takeoff/taxiing	LC	CD/FD	GC	CS
Detect ARTS failure	LC	CD/FD	GC	CS
Receive pilot/airline notice of ground hold required	LC	CD/FD	GC	CS
Receive FSS inquiry of flight plan availability	LC	CD/FD	GC	CS
Query FSS about flight plan availability	LC	CD/FD	GC	CS
Receive automatic handoff	LC	CD/FD	GC	CS
Observe initiation of automatic handoff	LC	CD/FD	GC	CS
Receive military request for assistance with, or ACF notice of, air evacuation	LC	CD/FD	GC	CS
Advise terminal controller of airport acceptance rate, limited visibility, runway braking action (= "Flow Requirement")	LC	CD/FD	GC	CS
Observe aircraft fly by airport rocking wings	LC	CD/FD	GC	CS
Detect alternating Mayday/RF transmission from aircraft	LC	CD/FD	GC	CS
Issue RVR to pilot for touchdown/midfield/rollout	LC	CD/FD	GC	CS
Receive pilot request to "Kill the Rabbit" (strobe) from ACF controller	LC	CD/FD	GC	CS
Inform terminal controller of aircraft departure/sequence order	LC	CD/FD	GC	CS
Select airport lighting	LC	CD/FD	GC	CS
Receive pilot request to "Shoot Cat 3A Approach"	LC	CD/FD	GC	CS
Verify Category 3A system is fully operational	LC	CD/FD	GC	CS
Contact fire department/dispatcher off the airport	LC	CD/FD	GC	CS
Select visual approach slope indicator lights on/off	LC	CD/FD	GC	CS

Figure E-3. Example Page Task Relevancy Checklist

APPENDIX F

ATC TASK ELEMENT MODULES

The following are the defined elements comprising the two TEMs representing ATC Mail actions of **receiving** and **sending** ATC Mail:

TEM M.1, Receiving ATC Mail =

M.1.1	DETECT_Message_Waiting_Indicator on Message Response Display
M.1.2	RECOGNIZE_Message_Classification *routine, priority*
M.1.3.1	EXECUTE_Acknowledge_Receipt_Of_Priority_ATC_Mail function
	O
M.1.3.2	SELECT_ATC_Mail_Message_Readout from Message Queue
M.1.4	EXTRACT_ATC_Mail_Message_Readout contents *as appropriate to task*
M.1.5	TERMINATE_ATC_Mail_Message_Readout on Message Response Display

TEM M.2, Sending ATC Mail =

M.2.1	DECIDE need for transmission of ATC Mail message
M.2.2.1	EXECUTE_Compose_ATC_Mail function *start*
M.2.2.2	* SELECT appropriate_Message_Composition_Template
M.2.2.3	INTRODUCE_Text_Message
	O
M.2.3.1	EXECUTE_Edit_ATC_Mail function *start*
M.2.3.2	SELECT appropriate_Text_Message from_Message_Composition_Menu
M.2.3.3	* MANIPULATE_Text_Message *edit*
M.2.4	INDICATE_Recipient
M.2.5	* SELECT_Priority_Designator
M.2.6	EVALUATE_Text_Message_in_Message_Preview_Area
M.2.7.1	EXECUTE_Compose_ATC_Mail function *send*
	O
M.2.7.2	EXECUTE_Edit_ATC_Mail_function *send*
M.2.8	* DETECT_Priority_Receipt_Acknowledgement

G.I. Message TEMs are labeled as:

G.I. Message, Receiving G.I. Message

G.I. Message, Sending G.I. Message

Voice Switching and Control System (VSCS) TEMs are identified for the following communication actions of en route and terminal controllers:

VSCS, Initiating G/G Communications

VSCS, Receiving G/G Communications

VSCS, Responding to Call Acceptance Priority

VSCS, Communicating Normally Air-to-Ground

VSCS, Initiating A/G Backup Communications

VSCS, Ensuring Guard A/G Communications

VSCS, Broadcasting Recorded Information

VSCS, Monitoring Others' Communications

VSCS, Recording Briefings

VSCS, Adjusting VSCS Displays/Receiving Modes

VSCS, Receiving VSCS Status/Reconfigurations

VSCS, Enabling VSCS Functions

VSCS, Monitoring ATIS Voice Recording

Comparable communications TEMs for the Tower Communications System (TCS) are identified as follows:

TCS, Initiating TCS G/G Communications

TCS, Receiving TCS G/G Communications

TCS, Communicating Air-To-Ground Via TCS

TCS, Ensuring TCS Guard Communications

TCS, Broadcasting ATIS Voice Recordings

TCS, Recording Position Relief Briefings

TCS, Adjusting TCS Displays/Receiving Modes

TCS, Receiving TCS Status

TCS, Enabling TCS Functions

TCS, Adjusting TCS A/G Configuration

APPENDIX G

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APPENDIX H

LIST OF ACRONYMS

The following acronyms have been used in reports of the Operations Concepts for Air Traffic Control operational positions of the National Airspace System. Not all are in general use or officially recognized.

A	Analytical (task type)
A&M	Aeronautical and Meteorological
AAR	Airport Acceptance Rate
AAS	Advanced Automation System
AASRAT	Advanced Automation System Requirements Action Team
A/C	Aircraft
ABV	Above Specified Altitude
ACCC	Area Control Computer Complex
ACF	Area Control Facility
ADIZ	Air Defense Identification Zone
AERA	Automated En Route Air Traffic Control
A/G	Air-to-Ground Voice Communications
AGL	Above Ground Level
AIRMET	Airman's Meteorological Information
ALSF	Approach Light System With Sequenced Flashing Lights
ALTRV	Altitude Reservation
AM	ARTCC/ACF Area Manager-in-Charge (composition graphs)
AMIC	ARTCC/ACF Area Manager-in-Charge
AMIS	Aircraft Movement and Identification Service
ANK	Alphanumeric Keyboard
AP	Acquisition Phase
AP	Advanced Automation Program
AR	ARINC (composition graphs)
ARF	Airport Reservation Function
ARINC	Aeronautical Radio, Inc.
ARSA	Airport Radar Service Area
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
AS	ARTCC/ACF Area Supervisor (composition graphs)
ASDE	Airport Surface Detection Equipment
ASOS	Automated Surface Observation System
ASR	Airport Surveillance Radar
ATA	Airport Traffic Area
ATA	Air Traffic Assistant
ATC	Air Traffic Control
ATCCC	Air Traffic Control Command Center
ATCRBS	Air Traffic Control Radar Beacon System
ATCT	Airport Traffic Control Tower
ATIS	Automatic Terminal Information Service
ATMS	Advanced Traffic Management System

AWOS	Automated Weather Observation System
BA	BASOPS (composition graphs)
BANS	BRITE Alphanumeric Subsystem
BASOPS	Military Base Operations
BRITE	Bright Radar Indicator Tower Equipment
BUEC	Backup Emergency Communications
CA	Conflict Alert
CARF	Central Altitude Reservation Function
CD	Clearance Delivery/ Flight Data Position (composition graphs, figures)
CDC	Computer Display Channel
CDRL	Contract Data Requirements List
CED	Computer Entry Device
CF	Center Field (figures)
CF	CFCF (composition graphs)
CFCF	Central Flow Control Function
CFWSU	Central Flow Weather Service Unit
CG	Composition Graph
CID	Computer Identification Number
CNCL	Cancel
CONUS	Continental United States (exclusive of Alaska)
CPSD	Cursor Positioning/Selection Device
CRA	Conflict Resolution Advisory
CRD	Computer Readout Device
CT	ARTCC/ACF Controller, terminal and/or en route, non-oceanic (composition graphs)
CT	TRACON Terminal Controller (pre-ACF)
CTA	Calculated Time of Arrival
CTA	Control Area
CUE	Computer Update Equipment
CVF	Controlled Visual Flight
CWA	Center Weather Advisory
DASI	Digital Altimeter Setting Indicator
D/A	D Controller, A Controller
DARC	Direct Access Radar Channel
D-BRITE	Digital Bright Radar Indicator Tower Equipment
DEC	Data Entry Control
DEWIZ	Distant Early Warning Identification Zone
DF	Direction Finder
DOD	Department of Defense
DOE	Department of Energy
DME	Distance Measuring Equipment
DOT	Department of Transportation
DSC	Data Systems Coordinator
DTG	Date/Time Group
DUKI	Dual Keyboard Input
E	Entry (task type)

E	Entry (task type)
E/DARC	Enhanced Direct Access Radar Channel
EDCT	Expect Departure Clearance Time
EFC	Expect Further Clearance
ELT	Emergency Locator Transmitter
EM	E-MSAW
E-MSAW	En Route MSAW
EOM	End of Message
EQF	Expanded Quota Flow
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
F	Function Message of the ACCC, ISSS, TAAS, or TCCC System for interposition coordination (composition graphs)
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FDB	Full Data Block
FDE	Flight Data Entry
FDEN	FDE Notation
FDEP	Flight Data Entry and Printout
FDIO	Flight Data Input/Output
FDP	Flight Data Processing
FIR	Flight Information Region
FL	Flight Level
FLAT	Flight Plan Aided Track
FLID	Flight Identification
FLIP	Flight Information Publication (DOD)
FPA	Fix Posting Area
FPL	Full Performance Level
FPS	Flight Progress Strip
FRC	Full Route Clearance
FS	Flight Service Station (composition graphs)
FSP	Flight Strip Printer
FSS	Flight Service Station (including Automated Flight Service Station)
GC	Ground Controller (composition graphs, figures)
G/G	Ground-to-Ground Voice Communications
GI	General Information
GID	Group Identification Number
GPS	Global Positioning System
HS	Headset (figures)
IAP	Instrument Approach Procedures
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
ID	Identification, or Identifier
IFR	Instrument Flight Rules
IFSS	International Flight Service Station

IMC	Instrument Meteorological Conditions
INSAC	Interstate Airway Communications
ISSS	Initial Sector Suite System
LC	Local Controller (composition graphs, figures)
LDB	Limited Data Block
LDIN	Lead-In Lighting System
LLWAS	Low Level Wind Shear Alert System
LORAN	Long Range Navigation
LS	Loudspeaker (figures)
M	ATC Mail or GI Message (composition graphs)
MALSF	Medium Intensity Approach Light System With Sequence Flashing Lights
MALSR	Medium Intensity Approach Light System With Runway Alignment Indicator Lights
MARSA	Military Authority Assumes Responsibility for Separation of Aircraft
MC	Military Mission Coordinator (composition graphs)
MFT	Meter Fix Time
MHA	Minimum Holding Altitude
MIS	Meteorological Impact Statement
MLS	Microwave Landing System
MM	Middle Marker (figures)
MMI	Man-Machine Interface
MOA	Military Operations Area
MPS	Maintenance Processor Subsystem
MSAW	Minimum Safe Altitude Warning
MSL	Mean Sea Level
MT	Meteorologist (composition graphs)
MTR	Military Training Route
MVA	Minimum Vector Altitude
N/A	Not Applicable
NADIN	National Data Interchange Network
NAS	National Airspace System
NATAC	National Air Traffic Coordination
NATCOM	National Communications
NAVAID	Navigational Aid
NM	National Airspace System Manager (composition graphs; formerly called Systems Engineer)
NMI	Nautical Miles
NOPAR	Do Not Pass To Radar
NORDO	No Radio
NOTAM	Notice to Airmen
NWS	National Weather Service
OC	Other Coordination Contact (composition graphs)
ODALS	Omni-directional Approach Lighting System
ODAPS	Oceanic Display and Planning System
OFPPE	Oceanic Flight Plan Position Extrapolation

OJT	On-the-Job Training
OM	Outer Marker (figures)
OMC	Oceanic Manual Controller
OTP	VFR-On-Top
OVR	Override
PAR	Preferential Arrival Route
PCA	Positive Control Area
PDAR	Preferential Departure/Arrival Route
PDB	Partial Data Block
PDR	Preferential Departure Route
PFT	Posted Fix Time
PI	Pilot (composition graphs)
PIDP	Programmable Indicator Data Processor
PIREP	Pilot Weather Report
PO	Pointout
POS (PSN)	Position (figures)
PVD	Plan View Display
QAK	Quick Action Key
R	Receipt (task type)
RA	Radar Approach
RAIL	Runway Alignment Indicator Lights
RDP	Radar Data Processing
RMMS	Remote Maintenance Monitoring System
RNAV	Area Navigation
RS	A scheduled record observation that also qualifies as a special observation (aviation weather) - see SA and SP
RSB	Radar Sort Box
RVR	Runway Visual Range
RWP	Real Time Weather Processor (formerly Central Weather Processor, CWP)
SA	A scheduled record observation (aviation weather)
SAFI	Semi-Automatic Flight Inspection
SAR	Search and Rescue
SCN	Specification Change Number
SE&S	System Environmental and Status
SE&SD	System Environmental and Status Data
SFP	Stored Flight Plan
SID	Standard Instrument Departure
SIGMET	Significant Meteorological Information
SLS	System Level Specification
SM	Statute Miles
SP	An unscheduled special observation indicating a significant change in one or more elements (aviation weather)
SRAP	Sensor Receiver and Processor (figures)
SRR	System Requirements Review
S/S (or SS)	Sector Suite
SSALF	Simplified Short Approach Light System With Sequenced Flashing Lights

SSALR	Simplified Short Approach Light System With Runway Alignment Indicator Lights
SSRVT	Sector Suite Requirements Validation Team
STAR	Standard Terminal Arrival
SWAP	Severe Weather Avoidance Program
TAAS	Terminal Advanced Automation System
TACAN	Tactical Air Navigation (UHF)
TBD	To Be Determined
TCA	Terminal Control Area
TCCC	Tower Control Computer Complex
TCS	Tower Communications System (for ATCT)
TELCO	Telephone Company
TEM	Task Element Module
TIM	Technical Interchange Meeting
T/M	Traffic Management
TM	ACF Traffic Management Unit (composition graphs)
TMC	Traffic Management Coordinator
TMS	Traffic Management System
TMU	Traffic Management Unit
TOCT	Tower Operations Concept Team
TPC	Tower Position Console
TRACAB	Terminal Radar Approach Control (Tower Cab)
TRACON	Terminal Radar Approach Control
TRSA	Terminal Radar Service Area
TS	Tower Supervisor (composition graphs)
TW	ATCT Controller (composition graphs)
UDI	Update Increment
UHF	Ultra High Frequency
UIL	User Interface Language
UNICOM	Universal Communications
V	Voice Communications - VSCS, TCS, and/or direct person-to-person (composition graphs)
VASI	Visual Approach Slope Indicator
VC	Verbal Communication (task type)
VFR	Visual Flight Rules
VH	Vehicle Operator (composition graphs)
VHF	Very High Frequency
VLF	Very Low Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omni-directional Range
VORTAC	Collocated VOR and TACAN
VSCS	Voice Switching and Control System (for ACF, ISSS, TAAS, ARTCC)
WC	Weather Coordinator
WX	Weather

APPENDIX I

INDEX

SUBJECT SECTION

A

V

W